# the Petroleum Engineer

...ds for Operating Men

JUNE • 1948

VOLUME XIX NUMBER 9


## MEETINGS

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**Irwin-Keasler Building, Dallas 1, Texas** **Phone:Central-4571**

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**Articles in The Petroleum Engineer are indexed by Industrial Arts Index**

A. B. C. **SUBSCRIPTION: 1 year, $2 — 2 years, $3** A. B. P.

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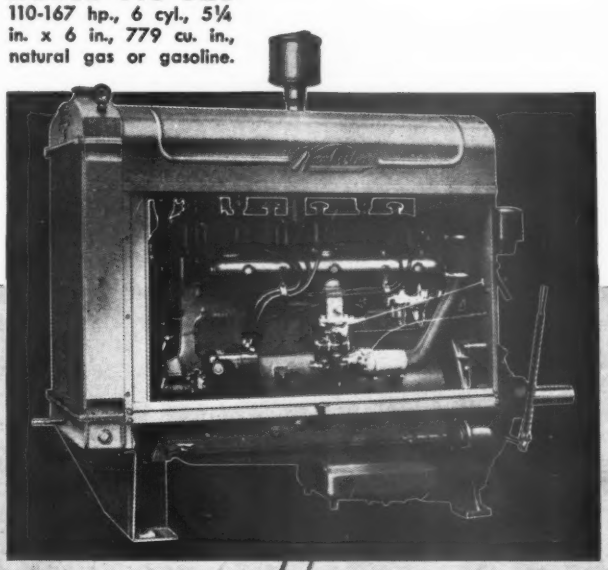

## Deck Coleman of Texas Pacific Coal and Oil Co. says WAUKESHA-POWERED Walker-Neer Spudder does "a fine job" deepening well to below 5000 feet

"One of the most complete drilling units that I have ever worked with, around, or on," says Mr. Deck Coleman. It's a Walker-Neer Spudder with a Waukesha Model 145-GKU Power Unit. And "having been a driller at one time," District Superintendent Coleman knows his rigs *and* oil field engines.

"The rig-up time is cut in half and rig-down time never takes over one and one-half hours. The unit was used in this district (Sundown, Texas) to deepen a well to below 5000 ft. All drilling was done with a hole full of oil and using no water to drill with.... Clutches and brakes are a great improvement over any rig or unit I have ever run.... All work on this well was done in second and third gears. There is more than enough power for this unit at 5000 ft." Last report on this unit from Odessa, Texas—"doing a fine job cleaning out and drilling deeper." *Get Bulletin 1225.*

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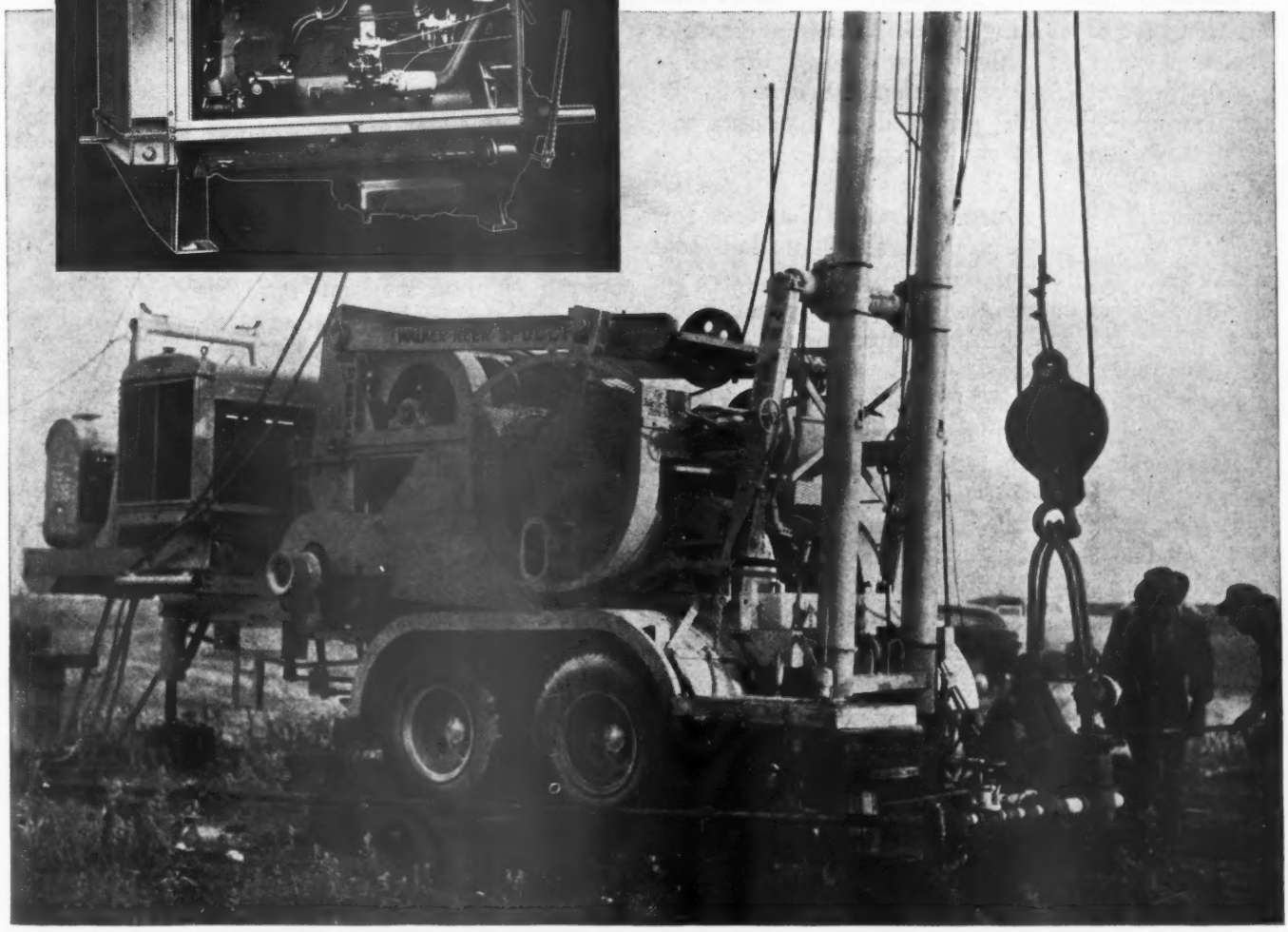
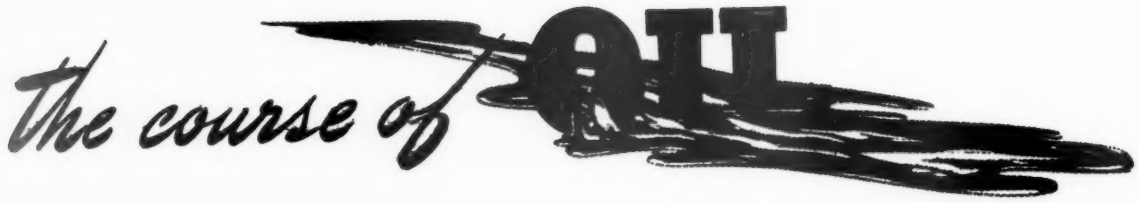


# WAUKESHA
## OIL FIELD POWER




## CABLE DRILLING MOTION—
### Need for scientific studies of instruments and actions

There is a definite need for the development of scientific data and measuring instruments in connection with the drilling motion of cable system drilling tools operating at the great depths now common to the industry. The problem would seem to be of much importance to the manufacturers of drilling equipment of the spudder type, to manufacturers of wire drilling cables, to operators, and to manufacturers of recording and indicating instruments.

Drillers are developed by spending much time in the observation of drilling motions and the trial-and-error method of learning to drill. Many drillers, after such experience, are able to interpret from the feel of the drilling cable the action that is taking place at the bottom of the hole, provided the operating conditions are somewhat conventional and the well is of moderate depth.

However, it is commonly admitted that very few men can determine accurately the bottom hole tool action from the feel of the drilling cable when the hole is of great depth. This is especially true in erratic formations and in unexplored areas where no previous experience exists.

Very little writing has been done from which the young driller can be taught in a scholastic way, or which he can use and study for self-improvement. The completion drilling of rotary drilled holes and the drilling of many formations that are not suited to the rotary method of drilling, together with the increased operations in the older, well-established cable tool fields, has resulted in an acute shortage of fully qualified cable tool drillers. Very few experienced drillers are inclined to reduce their knowledge to writing, and educators generally seem to have a lack of interest in the subject; consequently really thorough and valuable cable tool drilling courses are not available in the curricula of our petroleum engineering colleges. The result is that, generally speaking, petroleum engineers are usually unable to render proper guidance in the development of cable tool drillers. It would seem that a need exists for some study on the part of our petroleum engineering schools to supply this important phase of the petroleum industry with basic information and helpful leadership.

When drilling or fishing at great depths, the dead weight of the cable and its elasticity are of such extreme proportions that wall or fluid drag generally dampens out minor absorptions of energy generated through the transferring of cable load (tools) from and to bottom hole support to such a degree that the nerve sensitivity of the driller is frequently unable to interpret them in an accurate manner.

Consequently, it would seem that very sensitive instruments are as much needed in this industry as millivoltmeters are needed in the electronic field. In the actual drilling operation, the use of such instruments should prove to be an invaluable aid in the development of drillers and in the measure of their performance, as well as in the interpretation of structural changes.

One of the needed instruments is a recording tachometer that will record the drilling cable pay-off, the time element, and the cyclical speed variations of the power units with each reciprocation of the drilling stroke. Such an instrument would result in the development of a pattern or patterns of the most efficient drilling motions, line tensions, etc., for the different formations. Such patterns would undoubtedly indicate, through speed and motion changes and other factors, various formation changes as they are encountered. In addition, they would provide a rather definite record of the productive time of the equipment and personnel.

Such graph patterns might in turn be correlated with subsequent electric logs, caliper runs, and other geological and geophysical data that would prove of considerable value in the completion of the well and the preparing of it for production.

Instruments and mechanisms for the correlation of drilling cable stresses to an automatic method of cable pay-off to obtain more efficient drilling action might also be developed. Such an instrument could be adapted to the measurement of peak stresses by way of the crown block mounting and electrically, hydraulically, or pneumatically transmitting the impulse to a relay controlling a line pay-off or take-up mechanism effective upon the cable drum of the spudder. Thus the speed of the power unit might be held to a recurring cyclical similarity and the application of the input energy to formation penetration be made more uniform, all of which would be subject to graphic interpretation.

Here is a neglected problem that should have the attention of the educational and research groups of the industry, as well as the manufacturers and users who might participate in and benefit from such studies. —*Ferd J. Spang, President, Spang and Company, Butler, Pennsylvania.*

# IT TAKES ONLY ONE MAN TO CHANGE A *Free Pump*

The pumper alone can surface, change and reseat a Kobe *Free Pump*. In 30 minutes, he can do the job that under fixed type pumping would require four men fully eight hours.

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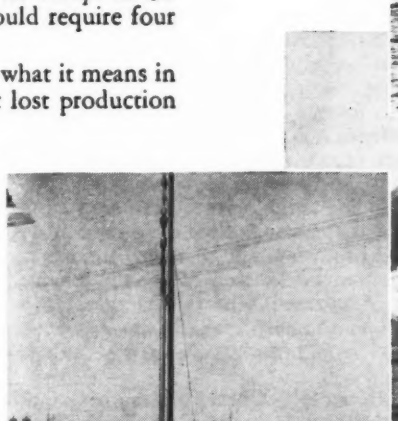

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***THESE ARE THE YEARS OF FREE PUMPING***

# SCANNING WASHINGTON'S OIL HORIZON

**By MILBURN PETTY**

WASHINGTON—Congress has been told that the petroleum industry desperately needs more steel to maintain present production levels—but there just isn't enough steel for all needs and neither the government, nor the steel industry nor the legislators are willing to assume responsibility for saying who is to go without to provide more steel for oil and gas.

Both the oil and steel industries are opposed to government controls. However, some steel men feel it would be helpful if there was some official indication of which projects should get preference. Government agencies have ducked on this. Federal Power Commission, for example, declines to say which of its approved natural gas lines are the most deserving of line pipe.

Several leading Republicans in Congress have threatened controls on steel unless success crowns the voluntary allocations program under the Taft Law (which was enacted last December in lieu of the mandatory controls recommended by President Truman).

Under the voluntary steel program, Commerce Department figures that the industry can make available 6,575,000 tons during the 12 months beginning with July. Of this total, Commerce has scheduled 1,725,000 tons for line pipe, 1,600,000 tons for oil country tubular goods, 300,000 tons for tankers and 250,000 tons for barges; programs for refining, marketing, and other oil transportation will come out of the remainder. Against this, the National Petroleum Council's steel committee (headed by Russell B. Brown, Independent Petroleum Association of America) has estimated total requirements of about 10,000,000 tons. Some oil companies will get some steel outside the program—but not enough to make up the difference.

Commerce Department is being prodded from several sides to channel more steel to independent producers. One idea being considered is to require all purchasers of oil country tubular goods to certify that the pipe will be used immediately. Another is to establish a "pool" for taking care of hardship cases as was done with fuel oil in the shortage areas last winter.

Difficulties of independent producers and drilling contractors in obtaining tubular goods are being studied by the Senate Small Business Committee. Chairman Wherry has threatened controls on steel if the small operator isn't taken care of, which, he admitted, sounded strange from him "because I was the one who killed OPA."

Speaking for the IPAA, Brown told Wherry's committee that the independents are losing ground. He submitted charts showing 26 large companies as having increased their percentage of net production from 55.7 in 1941 to 64.3 per cent in 1947 while the rest of the industry declined from 44.3 to 35.7 per cent in the same period. Brown also strenuously opposed any more shipments of steel for the Trans-Arabian Pipe Line.

Meanwhile, top officials of the Truman Administration are still reconsidering U. S. policy on Middle East oil, particularly the question of whether steel should be allocated to complete the TAPline project to the Mediterranean or to build more tankers instead. There are indications that, at the urgings of military leaders, the emphasis may be shifted to Latin America, particularly Mexico.

State Department is "softening up" on Mexico. A "token" allocation of steel, now in the making, may be followed with larger amounts as American operators get drilling contracts. And the idea of U. S. loans for developing Mexican oil is not nearly so abhorrent to State Department officials as it was.

Undoubtedly, this results from a constant hammering by the military for a "realistic" approach to Latin American oil development (they have the oil, we need it). Also, Defense Secretary Forrestal has been pressuring, at recent Cabinet meetings, for a thoroughgoing study of the whole oil situation, worldwide, including the Western Hemisphere's ability to supply requirements of the military and the Marshall Plan if the Middle East were to be cut off.

Apparently, Forrestal is backing the recommendation for a presidential oil commission made by the House Armed Services' oil subcommittee, headed by Congressman Short, Rep. Mo., which also urged government allocation of steel and rationing of petroleum products if a six-month trial of the voluntary programs in these two industries proves them inadequate. President Truman is understood to have leaned toward a special study of the oil situation, remarking that he, too, was confused.

Despite this being an election year, there will be several congressional oil investigations running during the summer. The small business committee of both the Senate and the House will study the plight of independent operators in the several branches. Other committees will seek to determine what steps, if any, are needed to avoid a fuel oil shortage next winter.

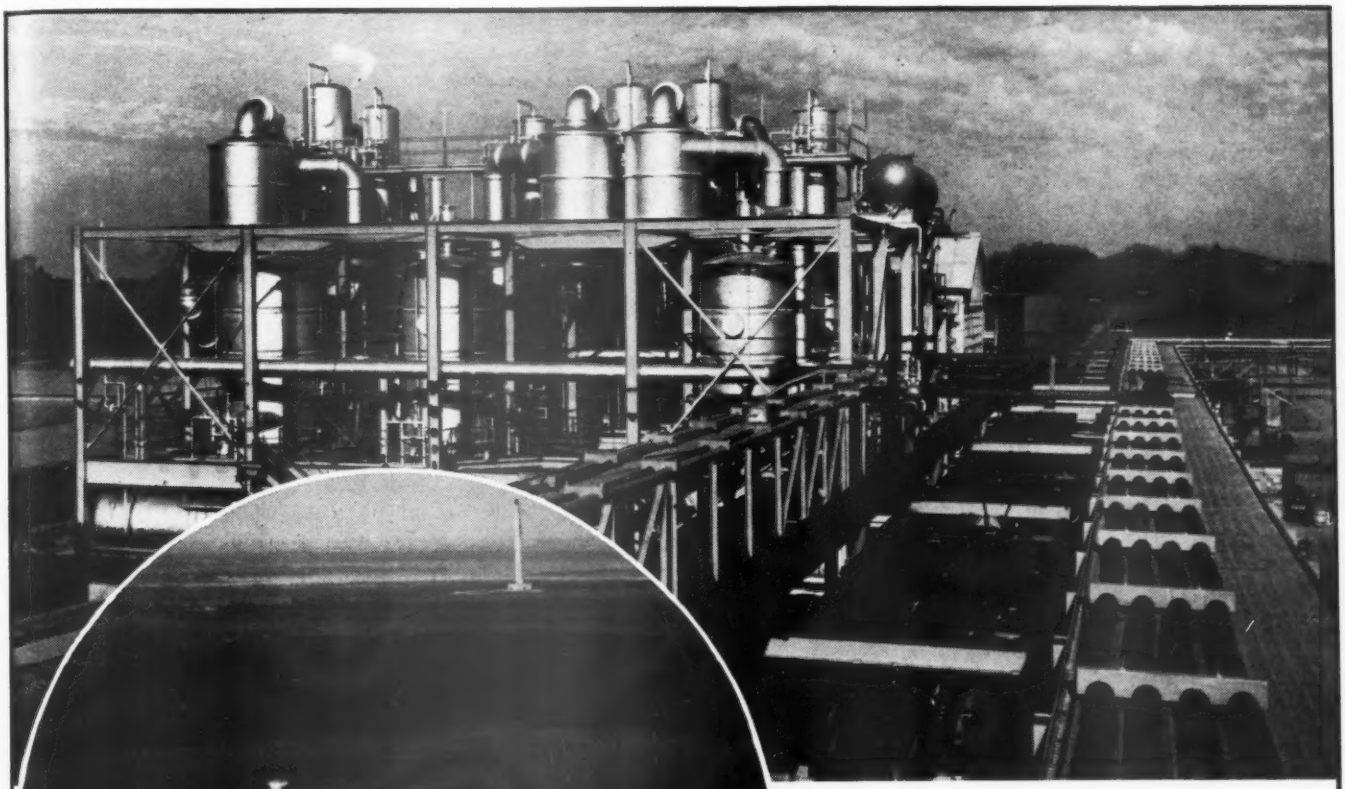
The government's victory in the "exclusive dealing" suit against the California Standard at Los Angeles may inspire the filing of more antitrust cases involving oil companies. Attorney General Clark recently reiterated that the government would never go to trial with the API-Mother Hubbard Case, pending since 1940. Clark did not say when this omnibus suit would be dismissed but did say it would be broken up into segment suits involving refining, transportation, and distribution. His remarks, at a press conference, revived expectations that a big oil case may be filed before the November elections.

But there is a ray of sunshine in the official gloom on oil. It comes from Interior Secretary Krug who, less than six months ago, was saying that if a price control law were voted he would freeze oil prices for 60 days to see if a rollback was needed, and, more recently, said the U. S. was 15 per cent short of meeting its requirements of crude oil.

Krug, asked by the White House for his views on the "need" for further economic controls on oil and gas, replied that there might be some spot shortages during the next 12 months but not serious enough to warrant the imposition of government controls. Total supply was estimated by Krug at 6,523,000 bbl a day as against demands totaling 6,453,000 bbl a day. (Krug's conversion to a more optimistic view on the oil outlook can be credited largely to Max W. Ball who, incidentally, is resigning from his post of director of Interior's Oil and Gas Division.)

Krug said that while the industry probably would not get all the steel it needs, still the deficiency—if not too large—would be unlikely to result in shortages sufficient to call for imposition of controls.

"Even with all developments favorable," Krug's report said, "supply and demand will continue in precarious balance. Since it may be expected that there will be at least minor adverse developments, it is believed that—although it is physically impossible to meet demands—the coming 12 months may see a repetition, on a reduced scale, of the local difficulties of the past 12 months. It is not anticipated, however, that these local difficulties will be of sufficient magnitude to warrant imposition of government controls over the supply and distribution of petroleum. In fact, with supply and demand in such close balance, and with the industry already engaged in extraordinary efforts to supply the small increment necessary to prevent local shortages, the imposition of government controls might have a disruptive effect that would make matters worse instead of better," Krug declared in his report to the White House.



# WE'RE PROUD OF DIAMOND'S NEWEST CHEMICAL WORKS

Diamond Alkali Company's newest chemical plant, the Houston Works on the Houston Ship Channel, recently went on stream, manufacturing chlorine and caustic for what it's able young president, R. F. Evans, so aptly described as "the living, growing, expanding chemical industry." Brown & Root, Inc. are proud to have been selected for engineering and construction of this great plant—proud of the part we have in the process industry in the Southwest, which is fast securing its position as a world chemical capital.

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# national petroleum situation

By H. J. STRUTH*,
Petroleum Economist

**PEAK DRILLING ACTIVITY.** More drilling rigs are in active service now than ever before. Facts developed by a survey show that 3,400 rigs are in operation; 2,000 rotaries and 1,300 cable tool outfits. Rotaries are averaging about 4,000 feet of hole monthly; the combined footage drilled by all rigs is about 3,000 feet monthly. With completions at a new peak level in May, it is likely that the industry will drill this year a total footage of more than 123,000,000 feet, compared with a total of 114,000,000 feet in 1947. Completions of at least 38,000 wells are expected this year, including service wells. Drilling operations in the first 5 months of this year are 18 per cent above last year. Wildcats are 23 per cent over last year.

**MORE GASOLINE.** Output of motor fuel in May attained a new high record of 2,563,000 bbl daily, an increase over last year of 13 per cent. Refinery yield of gasoline in May averaged 40.6 per cent, against 39.6 in April and the same recovery a year ago. Further improvement in this respect is expected over the next 2 months. With runs to stills at continuing higher rates, there is definite assurance that the industry can and will meet the expected heavy summer demand for gasoline. Motor fuel stocks on May 31 were 12 per cent above a year ago and represented 38 days' supply at present high rates of consumption. Demand in May averaged 2,705,000 bbl daily, against 2,405,000 bbl daily in May, 1947.

**FUEL OUTLOOK FAVORABLE.** Shortage talk has been discounted with respect to the gasoline supply and demand outlook for this summer and there is now every reason to discount also the shortage predictions made with respect to next winter's fuel oil supplies. Refinery runs to stills have reached a new peak of 5,606,000 bbl daily, against 4,947,000 bbl daily in May, 1947, an increase of 14 per cent. Fuel oil production is 20 per cent above last year and stocks of all fuel oils are 19 per cent greater. Late summer yield adjustments are expected to lift supplies of distillate fuel oils to new high levels and enable the industry to meet adequately next winter's increased requirements.

*Editor, *The Petroleum Data Book.*

## Comparative Statistics, May, 1948

*All figures are computed on a Bureau of Mines' Basis**

| | May 1948Ⓟ | April¶ 1948Ⓟ | May 1947 | This year to date | Last year to date | Per cent change |
|---|---|---|---|---|---|---|
| Wells drilling | 4,700 | 4,600 | 4,400 | 4,700 | 4,400 | + 7 |
| Total wells drilled | 3,384 | 2,942 | 2,744 | 14,339 | 12,147 | +18 |
| Development wells | 2,661 | 2,304 | 2,163 | 11,183 | 9,564 | +17 |
| Oil | 1,854 | 1,621 | 1,504 | 7,932 | 6,442 | +23 |
| Gas | 201 | 167 | 254 | 907 | 1,220 | −26 |
| Dry | 606 | 516 | 405 | 2,344 | 1,902 | +23 |
| Per cent dry | 22.8 | 22.4 | 18.7 | 21.0 | 19.9 | + 1.1 |
| Service wells | 189 | 160 | 183 | 870 | 729 | +19 |
| Wildcat wells | 534 | 478 | 398 | 2,286 | 1,854 | +23 |
| Oil | 90 | 63 | 67 | 330 | 290 | +14 |
| Gas | 18 | 25 | 20 | 102 | 66 | +55 |
| Dry | 426 | 390 | 311 | 1,854 | 1,498 | +24 |
| Per cent dry | 79.8 | 81.6 | 78.3 | 81.1 | 80.8 | + 0.3 |
| Crude supply* | 177,860 | 171,450 | 164,727 | 861,371 | 778,354 | +11 |
| Daily average | 5,737 | 5,715 | 5,314 | 5,667 | 5,155 | |
| Crude demand‡ | 180,140 | 171,000 | 162,797 | 859,691 | 764,937 | +12 |
| Daily average | 5,811 | 5,700 | 5,252 | 5,656 | 5,066 | |
| Crude stocks | 232,230 | 234,510 | 243,593 | 232,230 | 243,593 | − 5 |
| Days supply | 40 | 41 | 46 | 40 | 46 | |
| Natural gasoline production | 12,300 | 11,880 | 10,342 | 59,789 | 52,483 | +14 |
| Daily average | 397 | 396 | 334 | 393 | 348 | |
| Motor fuel production | 79,440 | 73,400 | 68,535 | 366,195 | 324,999 | +13 |
| Daily average | 2,563 | 2,447 | 2,211 | 2,409 | 2,152 | |
| Gasoline yield, per cent | 40.6 | 39.6 | 39.6 | 39.3 | 39.6 | − 0.3 |
| Motor fuel demand‡ | 83,850 | 74,040 | 74,565 | 350,520 | 322,221 | + 9 |
| Daily average | 2,705 | 2,468 | 2,405 | 2,306 | 2,134 | |
| Motor fuel stocks△ | 103,150 | 107,560 | 92,293 | 103,150 | 92,293 | +12 |
| Days supply | 38 | 44 | 38 | 38 | 38 | |
| Fuel oil production | 72,180 | 69,700 | 62,282 | 358,326 | 299,755 | +20 |
| Daily average | 2,328 | 2,323 | 2,009 | 2,357 | 1,985 | |
| Fuel oil demand‡ | 71,000 | 71,760 | 62,559 | 406,412 | 372,212 | + 9 |
| Daily average | 2,290 | 2,392 | 2,018 | 2,674 | 2,465 | |
| Fuel oil stocks | 88,050 | 79,350 | 74,271 | 88,050 | 74,271 | +19 |
| Days supply | 38 | 33 | 37 | 38 | 37 | |
| Refinery still runs | 173,800 | 164,840 | 153,348 | 827,457 | 726,528 | +14 |
| Daily average | 5,606 | 5,495 | 4,947 | 5,444 | 4,811 | |
| All refined stocks | 269,000 | 262,900 | 247,511 | 269,000 | 247,511 | + 9 |
| Days supply | 44 | 43 | 46 | 44 | 46 | |

## Supply and Demand—All Oils

| | May 1948Ⓟ | April¶ 1948Ⓟ | May 1947 | This year to date | Last year to date | Per cent change |
|---|---|---|---|---|---|---|
| Total supply, all oils | 196,390 | 189,380 | 180,744 | 951,279 | 860,665 | +11 |
| Daily average | 6,335 | 6,313 | 5,830 | 6,258 | 5,700 | |
| Total demand‡, all oils | 192,570 | 183,440 | 172,944 | 950,848 | 876,655 | + 8 |
| Daily average | 6,212 | 6,115 | 5,579 | 6,256 | 5,806 | |
| Change in stocks (total) | +3,820 | +5,940 | +7,800 | +431 | −15,990 | |

## Current Crude Oil Prices

| | | | |
|---|---|---|---|
| U. S. average | $2.61 | Louisiana | $2.62 |
| Texas | 2.61 | Arkansas | 2.43 |
| California | 2.42 | New Mexico | 2.40 |
| Oklahoma | 2.63 | Mississippi | 2.42 |
| Kansas | 2.62 | Illinois | 2.76 |
| | | Other states | 3.15 |

**Basic crude prices:**

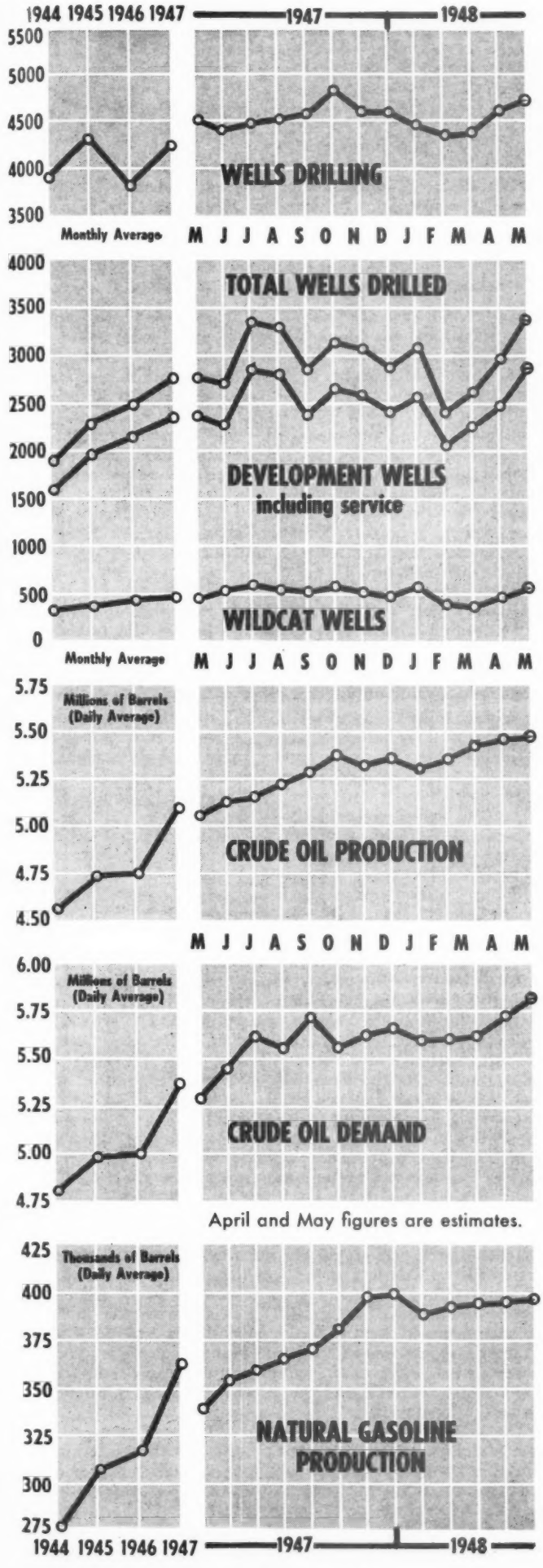
| | |
|---|---|
| Oklahoma-Kansas (36 gr.) | $2.57 |
| Texas Gulf Coast (36 gr.) | 2.86 |
| East Texas | 2.65 |
| West Texas (36 gr.) | 2.44 |
| California Signal Hill (26 gr.) | 2.41 |
| Pennsylvania, Bradford | 5.00 |

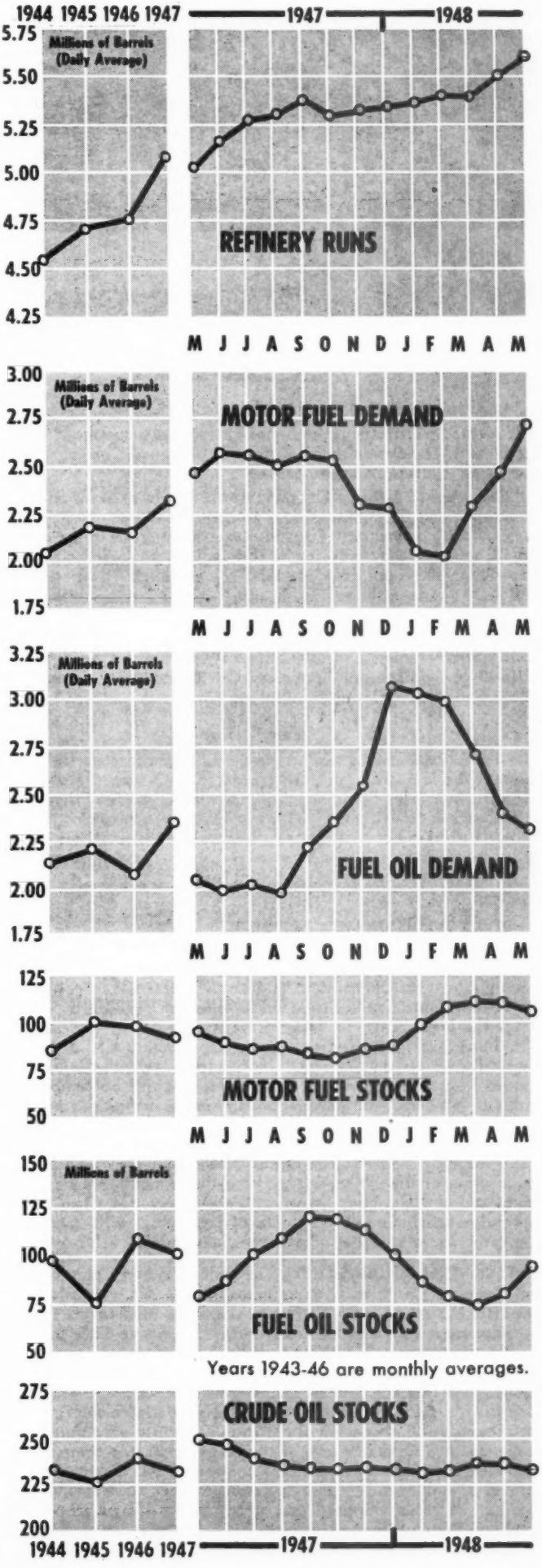
## Drilling and Production Statistics by States

| | May 1948Ⓟ | April 1948Ⓟ | May 1947 | This year to date | Last year to date | Per cent change |
|---|---|---|---|---|---|---|
| Wells drilled (excl service) | 3,195 | 2,782 | 2,561 | 13,469 | 11,418 | +18 |
| Arkansas | 27 | 21 | 38 | 126 | 116 | + 9 |
| California | 264 | 259 | 183 | 1,156 | 793 | +46 |
| Illinois | 226 | 125 | 144 | 804 | 736 | + 9 |
| Kansas | 308 | 214 | 203 | 1,127 | 955 | +18 |
| Louisiana | 220 | 178 | 121 | 821 | 512 | +60 |
| Mississippi | 39 | 23 | 54 | 157 | 171 | − 8 |
| New Mexico | 50 | 58 | 44 | 255 | 219 | +16 |
| Oklahoma | 374 | 332 | 301 | 1,578 | 1,534 | + 3 |
| Texas | 1,030 | 975 | 802 | 4,463 | 3,528 | +27 |
| Other states | 657 | 597 | 671 | 2,982 | 2,854 | + 4 |
| Wildcats drilled (incl above) | 534 | 478 | 398 | 2,286 | 1,854 | +23 |
| Arkansas | 6 | 8 | 8 | 36 | 23 | +57 |
| California | 38 | 36 | 30 | 145 | 142 | + 2 |
| Illinois | 31 | 25 | 41 | 140 | 138 | + 1 |
| Kansas | 51 | 38 | 42 | 176 | 143 | +23 |
| Louisiana | 24 | 23 | 25 | 103 | 100 | + 3 |
| Mississippi | 8 | 5 | 7 | 38 | 32 | +19 |
| New Mexico | 3 | 7 | 1 | 22 | 17 | +29 |
| Oklahoma | 83 | 61 | 50 | 332 | 316 | + 5 |
| Texas | 217 | 209 | 138 | 964 | 687 | +40 |
| Other states | 73 | 66 | 56 | 330 | 256 | +29 |
| Daily crude production | 5,460 | 5,435 | 5,033 | 5,388 | 4,880 | +10 |
| Arkansas | 88 | 88 | 81 | 87 | 80 | + 9 |
| California | 947 | 942 | 912 | 939 | 901 | + 4 |
| Illinois | 174 | 175 | 183 | 174 | 187 | − 7 |
| Kansas | 300 | 296 | 288 | 289 | 279 | + 4 |
| Louisiana | 481 | 480 | 433 | 478 | 423 | +13 |
| Mississippi | 123 | 122 | 91 | 119 | 87 | +37 |
| New Mexico | 128 | 130 | 107 | 128 | 106 | +21 |
| Oklahoma | 415 | 405 | 379 | 404 | 375 | + 8 |
| Texas | 2,433 | 2,431 | 2,225 | 2,409 | 2,116 | +14 |
| Wyoming | 147 | 145 | 119 | 143 | 114 | +25 |
| Other states | 224 | 221 | 215 | 218 | 212 | + 3 |

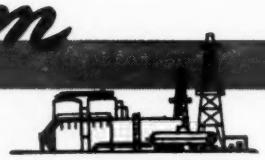
*Unless otherwise stated all figures represent thousands of barrels.
‡Total demand, including exports.
Ⓟ–Preliminary.
△Includes finished and natural gasoline.
*Includes domestic production and imports.
¶Revised.

Preliminary estimates based upon data supplied by American Petroleum Institute, U. S. Bureau of Mines, State Agencies, and other official sources.


1944 1945 1946 1947
1947
1948
WELLS DRILLING
Monthly Average
M J J A S O N D J F M A M
TOTAL WELLS DRILLED
DEVELOPMENT WELLS
including service
WILDCAT WELLS
Monthly Average
M J J A S O N D J F M A M
Millions of Barrels
(Daily Average)
CRUDE OIL PRODUCTION
M J J A S O N D J F M A M
Millions of Barrels
(Daily Average)
CRUDE OIL DEMAND
April and May figures are estimates.
Thousands of Barrels
(Daily Average)
NATURAL GASOLINE
PRODUCTION
1944 1945 1946 1947
1947
1948


1944 1945 1946 1947
1947
1948
Millions of Barrels
(Daily Average)
REFINERY RUNS
M J J A S O N D J F M A M
Millions of Barrels
(Daily Average)
MOTOR FUEL DEMAND
M J J A S O N D J F M A M
Millions of Barrels
(Daily Average)
FUEL OIL DEMAND
M J J A S O N D J F M A M
MOTOR FUEL STOCKS
M J J A S O N D J F M A M
Millions of Barrels
FUEL OIL STOCKS
Years 1943-46 are monthly averages.
CRUDE OIL STOCKS
1944 1945 1946 1947
1947
1948

# highlights in oildom



● **SEES NO RATIONING.** "It now appears certain that there will be no government rationing of gasoline this summer." This statement has been made by Ernest O. Thompson, chairman of the Texas Railroad Commission.

"Secretary of Interior Krug is reported to have made recommendations to the White House to the effect that while there may be 'spot' shortages of gasoline and heating oil in the coming 12 months, they will not be serious enough to warrant the imposition of government controls," he asserted.

Krug's report contains oil supply-demand estimates including imports and exports for the fiscal year beginning with July 1, 1948, as follows: Supply, 6,523,000 bbl a day including domestic production of 5,589,000 bbl a day and natural gas liquids, 419,000 bbl daily, and imports, 515,000 bbl daily. Demand, total, 6,453,000 bbl daily including domestic, 6,065,000 bbl daily, and exports, 388,000 bbl daily.

The report further states, "It is not anticipated, however, that these local difficulties will be of sufficient magnitude to warrant the imposition of government controls over the supply and distribution of petroleum. In fact, with supply and demand in such close balance, and with the industry already engaged in extraordinary efforts to supply the small increment necessary to prevent local shortages, the imposition of government controls might have a disruptive effect that would make matters worse instead of better."

● **STUDY PENNSYLVANIA RESERVES.** A study to determine how much crude oil lies under the stripper wells of Pennsylvania is being made under the direction of the State Topographic and Geologic Survey, Department of Internal Affairs, according to the Pennsylvania Grade Crude Oil Association. William S. Lytle of the Geologic Survey is supervising the study.

J. Paul Jones of Bradford, director of production for the Pennsylvania Grade Crude Oil Association, said the information on Pennsylvania's stripper well reserves will be combined with similar data from other states to create an up-to-date picture of the stripper well reserves of the nation. The national survey, covering all wells of this type in the United States, is being made by the Interstate Oil Compact Commission with the cooperation of the Independent Petroleum Association of America, and the National Stripper Well Association. The data to be obtained include the number of producing wells, production, productive acreage, oil reserves, and related information.

● **SEEK STEEL FOR GAS LINES.** The Federal Power Commission and eight state regulatory commissions in the Midwest and the Appalachian area have called upon the Steel Advisory Council to "take steps to assure steel for natural-gas pipe lines under the voluntary steel-allocation program."

In a letter sent to John Virden, director, Office of Industry Cooperation, Department of Commerce, the state and federal commissions pointed out that during the past winter emergency curtailments and allocation of natural gas supply were required in eight states served by one of the larger pipe line companies and that curtailments were also necessary on various other natural gas systems. In addition, conditions in Ohio, New York, and Pennsylvania required emergency allocation of gas. The resultant interruptions of service to industrial consumers, the letter said, "seriously disrupt the economy of some of the communities in which industries are located and the production of materials important to the national economy."

These conditions prevailed, according to the letter, even with limitations by state utility commissions upon or prohibition of service to new customers by local distributing companies under state jurisdiction and the authorization by the FPC between July 1, 1945, and January 15, 1948, of 9596 miles (1,967.100 tons) of additional interstate natural gas line construction.

"Despite the authorization of this great increase of interstate pipe line construction," the letter continued, "the pipe line companies have not completed and placed in operation any substantial portion of the facilities authorized. The delay in construction and alleviation of the serious shortage of natural gas to consumers is due principally to the unavailability of steel."

● **COMPACT SUMMER MEETING.** The problem of providing an adequate oil and gas supply without creating waste in the production will be squarely before the Interstate Oil Compact Commission and its 21 member states at the summer meeting to be held in the Roosevelt hotel, New York City, August 30 through September 1.

Program for the meeting will be built around the ability of the oil and gas producing states to meet consumer demand, how the demand can be met, and what the general public can do to insure an adequate supply.

Committee consisting of Harold C. Ostertag, Attica, New York, Jeff A. Robertson, Topeka, Kansas, Clarence T. Smith, Flora, Illinois, and Rex Belisle, Oklahoma City, was appointed by Governor Beauford H. Jester, Compact chairman, to complete the program details.

Although New York State has been a member of the Compact Commission since 1941, this is the first meeting to be held in the state. Time and place of the meeting were fixed by the executive committee at its recent meeting in Dallas, Texas.

● **WOULD REVISE FUEL STANDARD.** A recommended revision of fuel oils, commercial standard CS12-40, has been submitted to producers, distributors, and users of this product for written acceptance, according to an announcement by the commodity standards division of the National Bureau of Standards.

This revision was developed by Technical Committee E of ASTM D-2, and endorsed by the Standing Committee for the Commercial Standard. The purpose is to bring the standard into line with current refinery practice and burner construction. The specifications cover five grades of fuel oil for various types of fuel oil burning equipment. A suggested form of identification, to indicate compliance with the Commercial Standard, is also included.

● **COMPACT PUSHES SECONDARY RECOVERY.** Authority to permit or regulate secondary recovery operations already exists in most of the oil producing states, although in some instances it is probable that clarification or amplification of laws might be desirable, Paul D. Torrey, chairman of the Interstate Oil Compact Commission's Secondary Recovery Advisory Committee reported to the Compact's Executive committee at its monthly meeting in Dallas, Texas.

Reviewing laws relating to secondary recovery and cooperative pooling or unitization agreements as they may affect such operations, Torrey pointed out that many existing secondary recovery and pressure maintenance projects would not be successful in the absence of some form of pooling or unitization of property interests.

The Compact is urging statutory review by each state to insure that there are no legal obstacles to inauguration of most scientifically advanced recovery methods.

Several states have passed specific laws relating to secondary recovery operations, Torrey said. In others, authority to regulate such operations exists in the general conservation statute.

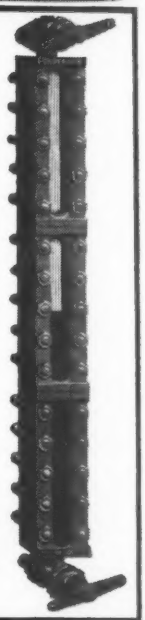
Torrey's report was divided into two sections, one relating to laws authorizing gas, air, or water injection for the purpose of increasing recovery, and the other concerning statutes permitting unit operation.

"The great benefits in the form of augmented recovery and lower development and operating costs, which result almost invariably from cooperative, pooling, or unitization agreements, with respect to secondary recovery, repressuring, pressure maintenance, and cycling operations, should receive wide publicity. As the public becomes better informed about these benefits, resistance to formation of such agreements should diminish."

# PENBERTHY

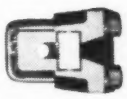
"REFLEX"

DROP FORGED STEEL LIQUID LEVEL GAGES



Liquid always shows black—empty space shows white. Preferred where the liquid level must be easily and positively visible, and when liquids are under high pressure or at high temperature. Made of alloy temperature resisting steel and are highest quality throughout. Liquid chamber made from solid block of steel to assure perfect alignment and rigidity. Conform with A.P.I.—A.S.M.E. requirements.

The "Reflex" is one of the complete line of Penberthy Gages that meet every liquid level gage requirement.



PENBERTHY INJECTOR CO.

DETROIT, MICH. Canadian Plant WINDSOR, ONTARIO

# PENBERTHY

"REFLEX"

WATER GAGE SET

For oil field, locomotive type and marine boilers. Water shows black — steam shows white; the water level is unmistakable. U-Bolt construction is strongest and simplest to service. Glass replaced by simply removing nuts on face of gage . . . unnecessary to work between gage and boiler. Conforms with A.S.M.E., Federal and State requirements when used for pressures specified by their respective codes.

This is one of the complete line of Penberthy gages that meet every liquid level gage requirement.

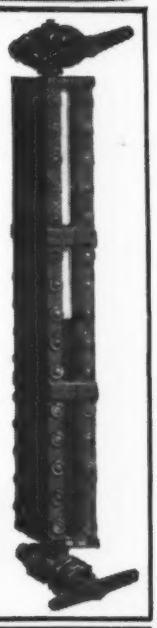
PENBERTHY INJECTOR CO.

DETROIT, MICH. Canadian Plant WINDSOR, ONTARIO

# PENBERTHY

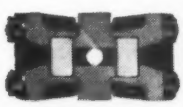
"TRANSPARENT"

DROP FORGED STEEL LIQUID LEVEL GAGES



Used to observe color and density of liquids under high pressures and/or temperatures. Construction exceptionally sturdy. Made of alloy temperature resisting steel, and are highest quality throughout. Liquid chamber made from solid block of steel to assure perfect alignment and rigidity. Conform with A.P.I.—A.S.M.E. requirements.

The "Transparent" is one of the complete line of Penberthy gages that meet every liquid level gage requirement.

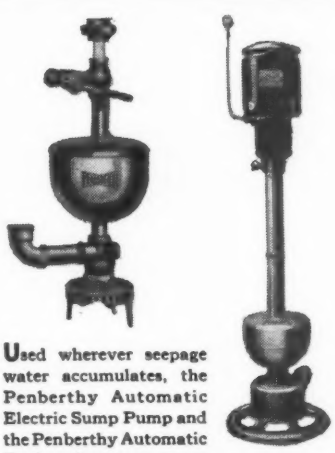


PENBERTHY INJECTOR CO.

DETROIT, MICH. Canadian Plant WINDSOR, ONTARIO

# PENBERTHY

SUMP PUMPS



Used wherever seepage water accumulates, the Penberthy Automatic Electric Sump Pump and the Penberthy Automatic Drainer (water or steam operated) have demonstrated their superiority in this service. Simple and rugged design—copper and bronze construction throughout.

PENBERTHY INJECTOR CO.

DETROIT, MICH. Canadian Plant WINDSOR, ONTARIO

# PENBERTHY

AUTOMATIC INJECTORS

The accepted method for assuring an uninterrupted supply of feed water to oil field boilers. Penberthy Automatic Injectors will supply feed water to boilers at minimum cost, are quickly and easily installed, reliable under most severe operating conditions, require little attention and no careful handling. Highest quality design and rugged construction.

PENBERTHY INJECTOR CO.

DETROIT, MICH. Canadian Plant WINDSOR, ONTARIO

# PENBERTHY

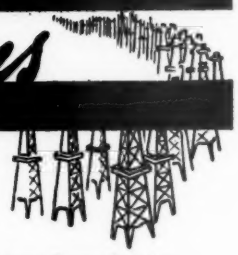
EJECTORS

Use the power of steam, air or water under pressure to lift liquids. Being simple jet pumps they have no moving parts and require no lubrication. A variety of models to meet different conditions. Also used as water heaters.

PENBERTHY INJECTOR CO.

DETROIT, MICH. Canadian Plant WINDSOR, ONTARIO

# current oil field operations



*Exploration wells that have found production.*

● **ILLINOIS.** Arvin Drlg 1 McDade NW SW 17-4n-9e Richland. Swb 30 BOPD Cypress 2665-81 ft.

Diamond 1 Tolliver-Woods NE SW NW 14-4n-7e Clay. 200 BOPH Cypress 2602-16 ft.

George S. Engle 1 Baltzell heirs SW NW 31-1s-11w Gibson. Swb 25 BOPD McCloskey 2299-304 ft.

● **INDIANA.** B. M. Heath & Indiana Farm Bureau 1 Joseph Fischer, Posey. 5-hr DST 275 ft oil Cypress 2248 and 2261 ft.

● **KANSAS.** S. H. Watson 1-B Mrs. Grace Jennings, blk 12 HT&B, Wichita. 5 BOPD 66-75 ft.

Lion 1 DeGeer NE NE SW 2-33-15w Barber. 4714 BOPD Viola 5179-83 ft.

Helmerich & Payne 1 Stucky SW SW SW 14-26s-6w Reno. 51 BOPH from 3660-64 ft.

Deep Rock 1 James SW SW NE 8-16s-1w Saline. 12 BOPD Mississippi 2672 ft.

Texas 1 Berland NE SE SW 19-10-19w Rooks. 160 BOPD Arbuckle 3807 ft.

Westgate Greenland 1 McClelland NW NE 4-9-19w Rooks. 18 BOPH Arbuckle.

Westgate Greenland 1 Mansz SE SW 18-19-10w Rice. Swb 3 BOPH 41° Arbuckle.

Hutchinson 1 Daetwiler SW SW NW 33-16-4e Dickinson. 50 BOPD Mississippian.

Derby & Kiowa Drlg 1 Tarrant SW NE SW 15-25-11w Stafford. Swb 8 BOPH Viola 3920 ft.

E. H. Adair 1 Wieland SE SE SE 26-19-10w Rice. 100 BOPD Arbuckle 3274-79 ft.

Wood River 2 Ney NW NW SE 31-15s-12w Russell. 222 BOPD Arbuckle 3550 ft.

● **KENTUCKY.** Sun 2 Binford 23-0-19 Union. Swb 75 B oil in 18 hr from Waltersburg 1792-808 ft.

Carter 1 Melton 14-0-23 Henderson. DST 760 ft oil Waltersburg 1745-61 ft.

Ashland 1 Royster 11-0-23 Henderson. 19 BOPD O'Hara 2502-11 ft.

● **LOUISIANA.** Kerr-McGee et al well, blk 32, 10½ mi off Point au Fer, Terrebonne. 600 BOPD from 1508-786 ft. New sand.

Magnolia 1 Doornbos-McPherson, Hurricane Creek field, Beauregard. 69 BOPD 48° from 8234-42 ft. New sand.

Magnolia 3-C Lutcher 24-14s-11w East Mud Lake field, Cameron. 129 BOPD 36.4° from 11,410-16 ft. Oil sand.

Halbouty & Del Cryer 1 Lane-Evann, Pine Island field, Caddo. 125 BOPD 36° Annona 1570 ft. New sand.

Superior 3 LL&E-State 12, Four Isle, Terrebonne. 64 B 46.7° cond & 5832 MCF gas daily from 10,748-64 ft. New sand.

Sohio 1 Burnell, SE of Iota field, Acadia. 291 BOPD 32.2° from 8666-98 ft. New sand.

Texas 6 State 40-17s-19e Horseshoe Bayou field, St. Mary. 433 BOPD 35° from 11,994-12,004 ft.

● **NEW MEXICO.** Mid-Continent 1-A U. D. Sawyer C SW SE 27-9s-36e Cross Roads, Lea. 3980 BOPD 42.5° Ellenburger 12,-115-255 ft.

Magnolia 1-X State 7-17s-34e Lea. 111 BOPD San Andres 4660-74 ft.

● **OKLAHOMA.** Continental 1 Sidney Eason SW/4 NW/4 NW/4 6-20-3w, Camp pool, Carter. 277 BOPD 36° Upper Tussey 4231-40 ft and 4254-75 ft. New sand.

Sohio 1 Kirt NW NW NW 19-1n-3e Murray. Swb 40 gal 17.2° oil for 14-hr Basal Oil Creek 1920-25 ft.

Gulf Coast Western 1 Ball SE NW SW 27-12n-10e Carey field, Okfuskee. 281 BOPD Gilcrease 2936 ft. New sand.

Carter 1 G. O. Christian C SE SW 5-1n-1w Garvin. 1 hr DST 8 B oil and 5000 MCF gas daily Pennsylvanian 5474-520 ft.

Sinclair Prairie 1 Hewitt C NW SW 3-4n-3w Southeast New Hope, Garvin. 49 BOPD 58° Chimney Hill 7552 ft. New sand.

Anderson-Prichard, Stephens, Fox & Fox 1 Freeman NW NE SE 26-3n-2w Garvin. 29 BOPH Second Deese 5473-503 ft.

Republic Natural Gas, C. L. Carlock and Carter 1 Masters SE NW SW 25-3n-3w Garvin. DST cond & 6000 MCF gas daily Hart 7210-35 ft.

E. Jordan 1 Favor SE SE SE 8-15n-1e Logan. 5 BOPH Bartlesville 5008-19 ft.

● **TENNESSEE.** J. H. Overstreet & D. H. Sparkes 1 Burton Davis, near Celina, Clay. 12 BOPD.

● **TEXAS.** Seaboard and Southern Minerals 1 M. G. Reed, 20 mi. n of San Angelo, Coke. 15-min DST 15-20 BOPH 47° Ellenburger 6184-6200 ft.

Phillips 1 Mrs. W. J. Weddell, C NE NE 72-M-GH&SA, Schleicher. 58 B oil in 16-hr Strawn 5630-700 ft.

Humble 1 Fred Turner, Jr., et al 18-11 GC&SF Pecos. Pump 39 BOPD 27.9° Yates lime 2870 ft.

McAlester Fuel 1 M. M. Fisher C SW SW 4-A36-PSL, Andrews. DST 22.5° oil Devonian 11,015-55 ft. DST oil 11,055-108 ft.

Skelly 3 W. T. Robertson, Sugar Valley field, Matagorda. 206 BOPD 34° from 9311-15 ft. New sand.

Walter Goldston 1 Gottschalt, Berry sur, Goliad. DST 350 BOPD Mackhank 7676-82; gas & cond from Luling 7601-09 ft.

Bay Petroleum and B. H. Hilburn 1 Mathews 39-149-DeWitt CSL, Jones. 2 hr DST 1500 ft oil Strawn 4640-60 ft.

C&B 1 Ollie Anderson 18-2-H&GN, Gaines. 73 BOPD Delaware 3835-906 ft.

Humble 1 Ellwood Estate-B, 56-18-SPRR sur, Sterling. 10-min DST 4000 MCF gas, 290 ft 47° oil Ellenburger 7962-80 ft.

General Crude well, 90-1-HG&TC, Fisher. DST 40 BOPH Cisco 3902-30 ft.

Lion B-1 Cowden, Crane. 14 BOPH from 2800 ft.

Howell & Howell 1 Nellie Prideaux, A. McMullen sur A-198, Young. 147 BOPD Strawn 2970-95 ft.

Rock Hill & W. E. Rowe 2 Elmer D. Wood, Nueces. 121 BOPD from 7490-94 ft.

J. W. Frazier 1 Lillie O. Hurlock, HT&B sur, Brazoria. 600 BOPD 34.5° from 9095-116 ft.

Stanolind 3 Burnett, Pratty sur, Carthage pool, Panola. 45-min DST 39 ft cond & 3000 MCF gas daily, Up. Pettit 5722-57 ft.

American Republics 1 Roy Jones 1648-TE&L, Young. 1-hr DST 90 CF gas & 30 ft oil from 3464-82 ft.

L. M. Lockhart 1 Richardson, Driscoll Ranch, Nueces. 79 BOPD from 7312-18 ft.

Floyd Karsten 3 Zoe B. McDonald, Liberty. 46 BOPD 41° Cockfield 5775-78 ft.

M. J. Mitchell 1 T. C. Partney 17-BAL, Shackelford. 253 B oil in 12 hr Marble Falls 4322-32 ft.

Deep Rock & Jennings 1 Ella Andrews 284-BBB&C Throckmorton. 28 BOPD Marble Falls 4767-91 ft.

J. E. Smith 1 T. J. Caldwell, 13-mi. e of Austin, Bastrop. 100 BOPD from 1608 ft.

Anderson-Prichard & Vickers 1 M. Frances Foster C SW SW 12-15-H&TC Sterling. 846 BOPD 26.5° Wichita-Albany 4252-306 ft.

Warren 1-K Allar TE&L-1653 Young. DST 15 BOPH Caddo 3635-39 ft.

Seaboard 1 Campbell T&P sur, Howard. 1162 BOPD 42° Pennsylvanian 7877 ft.

Fullerton & Ryan 1 C. McDonald Calhoun. Oil DST Frio-Vicksburg 9645-61 ft.

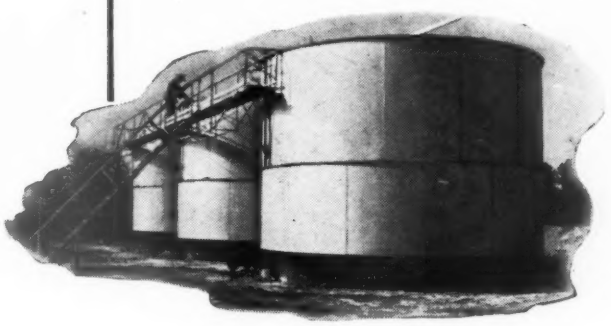
G. J. Hollandsworth 1 Alice Crain, J. B. Sweeten sur, Panola. 36,000 MCF gas and 1152 B 63.6° cond. Lower Pettit 6538-50 ft.

● **WYOMING.** Sinclair Wyoming 2 Grayton, Lost Soldier field, Sweetwater. DST 10 BOPH Cambrian 5961-6026 ft. New sand.

Pure 1 C NW SE 11-33n-84w West Poison Spider field, Natrona. 500 BOPH 45° Frontier 14,309 ft. Deepest oil production.

# The acid test!

"THE ACID TEST" OF EVERY ACIDIZING TREATMENT COMES WHEN YOU GAUGE YOUR STOCK TANKS. *DID* PRODUCTION INCREASE? HOW *MUCH?*



## *Production Increases tell the story of Dowell Acidizing!*

Many factors affect the success of acidizing treatments. Of prime importance are the accuracy and completeness of well data, interpretation of that data, and preliminary planning. Oil operators have found, too, that calling Dowell is a good step toward a successful completion or rework program.

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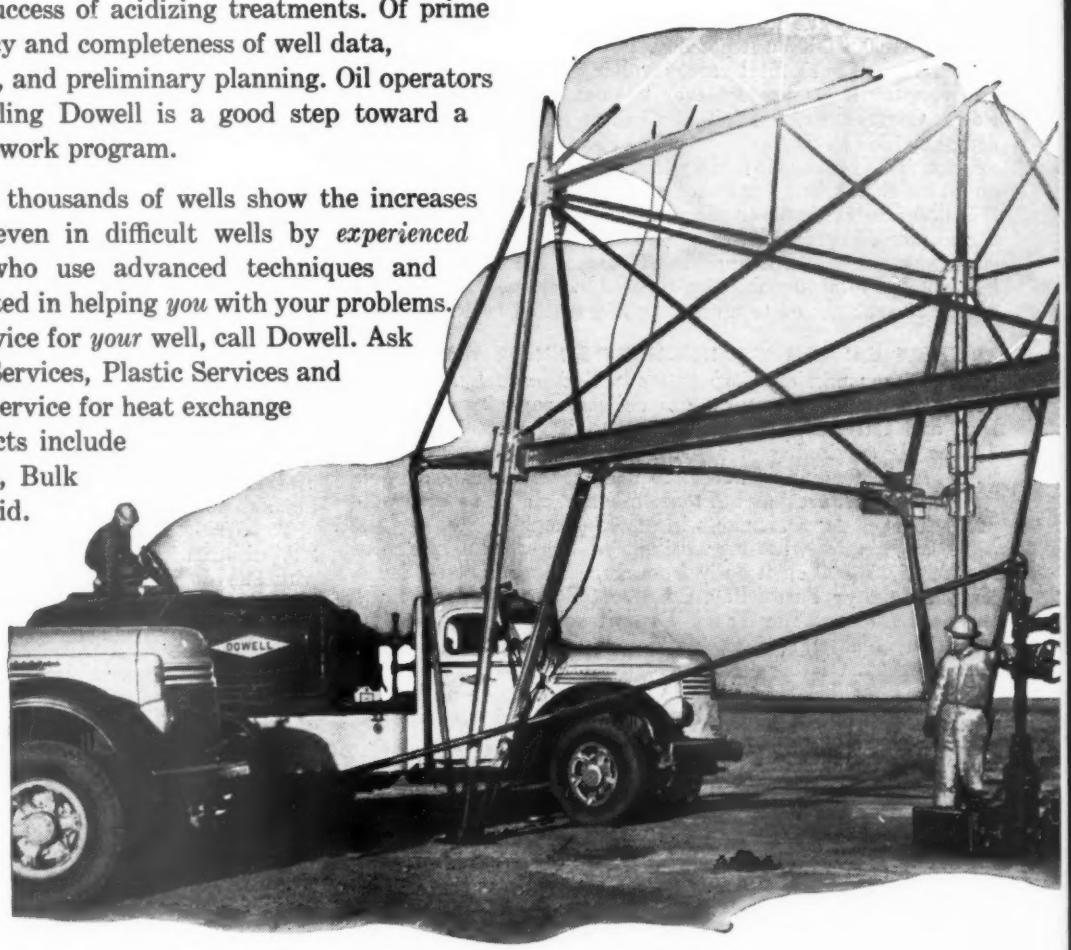


**EXAMPLE:**

*Initial production on a well completed in the Simpson Dolomite of North Texas was 1½ BOPD with opinions expressed that it had no chance to do better. A Dowell Electric Pilot Survey showed nearly all the relative permeability in 12 of the 75 feet of open hole. The well was selectively acidized in three stages using the Electric Pilot to hold the acid to the tighter zones. Results—50 BOPD.*

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# pipeline developments

● **TRANSCONTINENTAL PROJECT APPROVED.** Trans-Continental Gas Pipe Line Company of Longview, Texas, has FPC authorization to construct and operate a natural gas pipe line extending from the Gulf Coast area of Texas and Louisiana to the east bank of the Hudson River at 132nd Street in New York.

The proposed project, which is intended to supply natural gas to the New York metropolitan area and other parts of the Middle Atlantic section, is planned to consist of approximately 1840 miles of pipe, 15 compressor stations, and other appurtenant facilities. According to the company's estimates, it may cost between $151,000,000 and $180,000,000 and will be ready for operation in the fall of 1950. It will have a capacity of as high as 340,000,000 cu ft per day.

The Trans-Continental case, involving the largest and most costly natural gas project ever to come before the Federal Power Commission, was initiated in December, 1946 when the company filed its first application. On March 31, 1948 the Commission issued an order finding that the company had not demonstrated that it had firmly committed gas supplies.

In the interval between March 31 and the commencement of the reopened hearings on May 11, the company negotiated purchase contracts with a number of natural gas producers and brought the total amount of estimated reserves available to it over a 20-year period to more than 2½ trillion cu ft.

● **TEXAS EASTERN EXPANSION GETS UNDER WAY.** Texas Eastern Transmission Corporation will construct new facilities to increase the natural gas delivery capacity of its Big Inch and Little Big Inch pipe lines to 508,000,000 cu ft per day by the beginning of 1949. Texas Eastern had asked the FPC for the temporary permit to undertake this construction, R. H. Hargrove, president of the company, said, in order to supply natural gas to consumers in the Appalachian area.

Texas Eastern will buy casinghead gas at the combined rate of 55,000,000 cu ft daily from three Texas fields: Silsbee, Hardin County; Turtle Bay, Chambers County, and Hastings, Brazoria County. The Texas Eastern schedule calls for installation of a total of 239,900 compressor hp by the beginning of 1949. Of this amount, 73,900 hp will be installed in seven reciprocal compressor stations; the balance of 166,000 hp will be installed in 14 centrifugal compressor stations of a new type pioneered by the company.

Immediate construction of three new gathering lines is planned by Texas Eastern. Twenty miles of 8-in. pipe line will be built from the company's existing line in Harris County, Texas, to the Stanolind Oil and Gas Company gasoline extraction plant in Hastings field. At the same time in Louisiana two 10-in. lines, one five miles, and the other two miles long, will be laid from the Little Big Inch line to new gasoline extraction plants being built by The California Company and Southwest Gas Producing Company in the Hico-Knowles field. Work will begin later on another 10-in. pipe line extension, running 17.2 miles from the Little Big Inch to the Silsbee field in Texas.

Increasing the capacity of its pipe line system to 508,000,000 cu ft per day, including changes in compressor stations, installation of additional horsepower and extension lines to new gas sources, will bring the total capital cost of system to about $182,700,000, Texas Eastern estimated. This is approximately $10,300,000 more than the overall capital cost of the Inch Lines system at the originally planned delivery capacity of 433,000,000 cu ft daily.

● **TENNESSEE GAS INCREASES CAPACITY.** The pipe line system of the Tennessee Gas Transmission Company is now delivering approximately 370,000,000 cu ft of natural gas daily, an increase of 45,000,000 cu ft since the first of the year, President Gardiner Symonds announced. He said that despite delays in the company's construction program due to extraordinarily severe winter weather, approximately 60 miles of 26-in. loop line were laid in the first quarter of this year.

Tennessee Gas, which operates a gas pipe line from the Rio Grande to West Virginia, is at work on a loop that will increase the system's capacity from its present 370,000,000 cu ft daily to 600,000,000 cu ft daily. It also has received permission from the FPC to lay 150 miles of 30-in. loop, which will add another 60,000,000 cu ft daily to the system. This last authorization is part of a third complete line which the company plans to lay.

The company's application to increase the system's capacity to a billion cubic feet daily and extend service at a cost of $125,000,000 to a point near Buffalo, New York, is before FPC.

● **LONE STAR GAS PLANS ADDITIONS.** The Lone Star Gas Company, Dallas, Texas, plans to construct natural gas facilities in Oklahoma and Texas at an estimated cost of $1,059,500. Facilities are to include installation of an aggregate of 2400 hp units in the Fox Central compressor station, Carter County, Oklahoma, and an aggregate of 3620 hp units in compressor stations in Cook, Knox, and Grayson Counties, Texas.

● **WORK BEGINS ON KANSAS AND NEBRASKA LINES.** Kansas-Nebraska Natural Gas Company, Inc., plans the construction and operation of additional natural gas pipe line facilities in Kansas and Nebraska. The facilities have been estimated to cost $3,121,133.

The additional facilities were requested by the company to meet demands of its existing markets and to provide additional gas for new markets in Kansas and Nebraska. With the proposed construction, the existing delivery capacity of Kansas Nebraska's natural gas system would be increased from 105,000,000 cu ft per day to 123,000,000 cu ft.

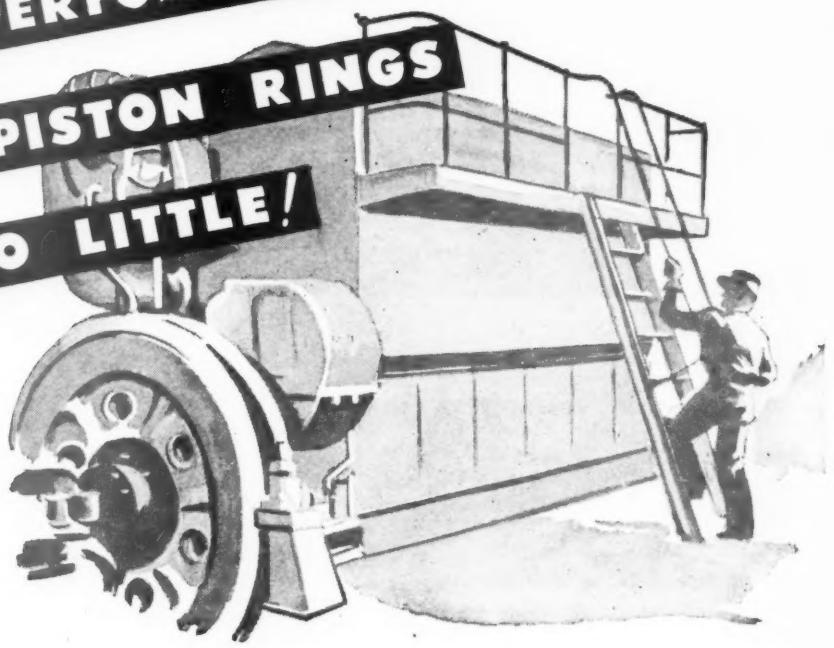
Facilities in the project include partial looping and replacements of the company's Scott City-Cambridge and Scott-City-Holdredge lines; continuation of the existing Otis-to-Stockton line on to Phillipsburg; construction of 35 miles of new line north of Elm Creek in Nebraska, lateral lines, and town border stations to serve the additional towns and installation of one 1600-hp compressor unit at its Deerfield compressor station in the Hugoton Field.

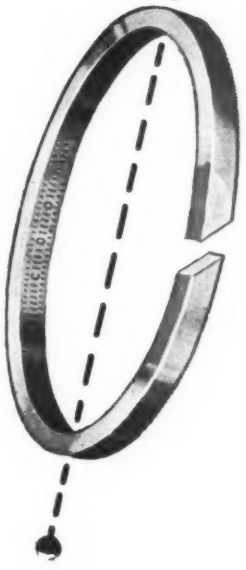
● **PENNSYLVANIA TO HAVE NEW FACILITIES.** United Natural Gas Company, Oil City, Pennsylvania, has completed plans to enlarge its natural gas transportation system at a cost of $3,057,500. New facilities will include replacement of about 20½ miles of 12-in. pipe line in Elk County, Pennsylvania, with 22¾-in pipe; construction of about 29 miles of 12¾-in. pipe line between a storage field and a compressor station in Elk County, about 4½ miles of 10 or 12-in. pipe line from a proposed storage field to a compressor station in Jefferson County, Pennsylvania, several short connecting lines in Jefferson and Clarion Counties and installment of an aggregate of 1650 hp in existing compressor stations.

● **HEARING SCHEDULED ON MID-WEST LINE.** The Federal Power Commission has set June 28, 1948, to commence public hearing in Washington, D. C., on an application filed by Trunkline Gas Supply Company, Wilmington, Delaware, and Washington, D. C. The application requests authorization to construct and operate a natural gas pipe line system beginning in Wharton County, Texas, and extending north through Arkansas and Missouri to Keokuk County, Iowa. The facilities proposed include construction and operation of a 30-in. gas transmission pipe line approximately 855 miles long, and appurtenant facilities for gathering, dehydration, compression, transmission and delivery of natural gas through the proposed system, including 60 miles of 24-in. feeder lines and 12 compressor stations with an aggregate of 182,400 hp. The overall cost of the facilities, including working capital, has been estimated at $74,266,507.

Service to be rendered as proposed by the company is primarily a "wholesale service" to be offered to natural gas companies at such points along the applicant's system as may prove convenient to the customers.

# YOUR DIESEL PERFORMANCE DEPENDS ON PISTON RINGS THAT COST SO LITTLE!





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YOU engineers who operate Diesels are well aware of the necessity for efficient engine performance in these days of rising costs.

For that reason many of you can appreciate the importance of piston rings in maintaining the desired, low-cost-of-operation efficiency. This is because the primary function of the rings is to "bottle up" clyinder pressures and to put these pressures to work in the form of useful power.

This ring function, in fact, is so important that it may be said that the efficient performance of your engines is in direct relation to the proper functioning of the rings. Experienced engineers, knowing this to be the case, realize that with piston rings that cost so comparatively little, they cannot afford to install anything but the best . . . and to many this means Cook Graphitic Iron Rings because they eliminate compression losses—reduce the rate of cylinder wear—restore new engine performance after cylinders become worn—and improve efficiency generally.

If this is news to you, ask for the story of Cook Rings—the rings that are custom made of unique materials to special designs so that Diesels will perform more efficiently. WRITE DEPT. 5-C

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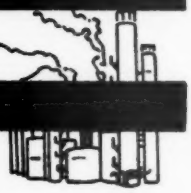
# refining and natural gasoline activities



● **SUN TO ENLARGE TOLEDO PLANT.** Expansion of Sun Oil Company's Toledo refinery over the next two years at a cost in the neighborhood of $16,000,000 was announced by Clarence H. Thayer, vice president in charge of manufacturing.

The proposed expansion includes construction of a 30,000 bbl-a-day catalytic cracking plant, a crude distillation unit, a vacuum unit, a large gas recovery plant, a new polymerization plant, and auxiliary units and equipment required by the major installations.

The proposed expansion will constitute a complete refinery in itself, Mr. Thayer explained, asserting that upon its completion the capacity of the present refinery will be almost doubled. The clearing of the site for the new installations will begin by June 1 and major construction work is expected to be completed by the end of next year.

When the job is done, he said, Sun's Toledo refinery "will rank among the 20 largest refineries in the country and few will exceed it in catalytic cracking capacity." Sun Oil in the nineteen-thirties pioneered the utilization of catalytic cracking upon a large scale commercial basis. Sun's Toledo refinery now has one of the earliest and largest catalytic cracking units in the country.

● **LION OIL TO EXPAND CHEMICAL FACILITIES.** Lion Oil Company will expand its chemical plant facilities at El Dorado, Arkansas, with a project estimated to cost $3,500,000, according to an announcement by Board Chairman T. H. Barton. The new construction, to be tied in with the present operations, will increase the anhydrous ammonia capacity of the chemical plant from about 430 tons to 570 tons per day, an increase of 32.6 per cent. Plant enlargement is to be designed and supervised by Chemical Construction Corporation of New York, the same company having acted as architect-engineers and having supervised construction and initial operation of the present ammonia plant. Engineering work is now in progress and actual construction is expected to start in June, 1948, with completion of the entire project scheduled for the spring of 1949.

● **TO LICENSE TPC UNITS.** The Socony-Vacuum Oil Company, Inc., announced that it has authorized the Vulcan Copper and Supply Company of Cincinnnati, Ohio, to design and erect units developed by Socony-Vacuum to produce ethylene and additional basic materials for the chemical and other industries.

Known as Thermofor Pyrolytic Cracking, the process uses low grade petroleum and residual oils. Ethylene, an important raw material used extensively in the manufacturing of synthetic rubber, various plastics, alcohol, detergents and tetraethyl lead, has been obtained heretofore from petroleum as a by-product present in such low concentrations as to require expensive separation processes.

The TPC process was developed by Socony-Vacuum at its laboratories in Paulsboro, New Jersey, after extensive research. It is essentially a high-temperature conversion accomplished without the use of a catalyst by contacting the oil charge with a moving bed of inert granules raised to high heat. This vaporizes the oil and induces rapid high-temperature reaction. The heat-transfer granules pass continuously through contacting and heating stages. The resultant unsaturated gaseous hydrocarbons consist primarily of ethylene.

● **SHELL BUILDS NEW CHEMICAL PLANT.** The first unit in what may become a complete plant for making oil-derived synthetic detergents used in household and industrial soaps, cleansers and emulsifying agents, is being constructed by the Shell Chemical Corporation in Wood River, Illinois, W. P. Gage, vice president announced. A subsidiary of Shell Oil Company, Inc., Shell Chemical will process raw materials received from Shell Oil's refinery in Wood River, near St. Louis.

The new unit, which will manufacture an intermediate chemical used in making finished detergents, represents part of an investment of more than $9,000,000 that Shell companies have made in expansion and improvement programs in the St. Louis area during the last two years. Among other expansion projects, still in the planning stage, are a new marine terminal in St. Louis and a large crude oil tank farm at Wood River.

Shell Chemical now operates plants at Dominguez, Martinez, and Pittsburg, California, and Houston, Texas.

● **SUNRAY PLANT SETS RECORD RUN.** The three-furnace Dubbs thermal cracking unit at Sunray Oil Corporation's refinery at Allen, Oklahoma, was voluntarily shut down for inspection and clean out after having established the longest continuous run on record for a Dubbs thermal cracking unit, it was announced by F. L. Martin, executive vice president. The cracking unit started this record run at 9:00 a.m. November 10, 1947, and continued operation until 7:00 a.m. April 29, 1948.

While establishing the record run of 170 days and 22 hours, the unit processed 1,373,675 bbl of charging stock, an average of 8037 bbl daily. The previous record run by a Dubbs thermal cracking unit was 168 days, according to Universal Oil Products Co., licensors of the process.

● **WORK BEGINS ON CASPER REFINING EXPANSION.** The Socony-Vacuum Oil Company, Inc., announced that practically all phases of a general expansion, improvement, and rehabilitation program are now under way at its refinery in Casper, Wyoming, and that completion of the program is scheduled for next December. The program will double the refinery's current 3,000-bbl-per-day capacity.

The Catalytic Construction Company of Philadelphia, Pa., is the general contractor for the project, handling mechanical design and field construction under the supervision of Emory M. Skinner, chief refinery engineer of Socony-Vacuum's White Eagle Division.

● **MONSANTO BUYS SYNTHETIC RUBBER UNIT.** Monsanto Chemical Company announced the purchase of a surplus synthetic rubber plant from the War Assets Administration for $169,500. The plant, adjacent to the Monsanto Plastics Division plant in Springfield, Massachusetts, was built by the company for the government during the war. It was originally used for the production of polydichlorostyrene—a plastic material with exceptionally high electrical insulating properties. The material was used during the war for essential parts of radar equipment.

The plant was then partially reconverted and materials for synthetic rubber were produced for the Office of Rubber Reserve. When this work was completed, Monsanto leased the plant from the government and began the manufacture of an oil additive. Manufacture of oil additives will be continued in this plant, the company said, if sale is approved.

● **CITIES SERVICE ADDS TO PAMPA UNIT.** A modernization program for the Cities Service Oil Company's Pampa, Texas, natural gasoline plant has been announced by A. W. Ambrose, president. Design and erection of the new facilities will be handled by Walco Engineering and Construction Company of Tulsa. Actual work is expected to begin sometime this summer.

In redesigning the plant, provisions were made ultimately to process 18,000,000 cu ft of gas daily. The Cities Service plant will be one of two that will boost, treat, and dehydrate the gas supplied to the West Pampa Repressuring Association's secondary recovery project in the area.

The program will include the expansion of compressor capacity with the addition of approximately 2600 hp, installation of absorbers that will operate at 500 psi pressure, new distillation equipment and cooling facilities, new fractionators and treating facilities, a boiler plant, water treating plant, gas treaters, gas dehydrators and additional high-pressure storage for liquid hydrocarbons.

**All types of weather were encountered in the year of construction. Operating in Texas, ditcher's progress is hindered by water.**

# Longest oil line since war completed

By FRANK H. LOVE, *Managing Editor*

THE longest crude oil line to be constructed since the end of World War II is now in operation between Corsicana, Texas, and Patoka, Illinois—a distance of 647 miles. Constructed by Magnolia Pipe Line Company, the first oil emerged at Patoka June 2, a year to the day from the time work on the project began.

**EXCLUSIVE**

The section from Corsicana to Conway, Arkansas, representing approximately half of the project, was completed by the first of the year and has been in use to transport crude oil as far as Mayflower, Arkansas, from which point it has been shipped to destination in tank cars. The last portion of the line was completed May 16. After testing with water at a pressure of 750 psi, filling of the line with crude oil was begun.

The line is designed for a rated capacity of 100,000 bbl a day at 700 psi operating pressure.

Covering a construction period of a year, as it did, there was ample opportunity to encounter all types of weather, and this seemed to be especially true during the past winter when particularly severe snows and rains occurred. From the first of January to the middle of March, especially, was progress limited. From April 1 to May 16, however, exceptionally good time was made, 164 miles being laid.

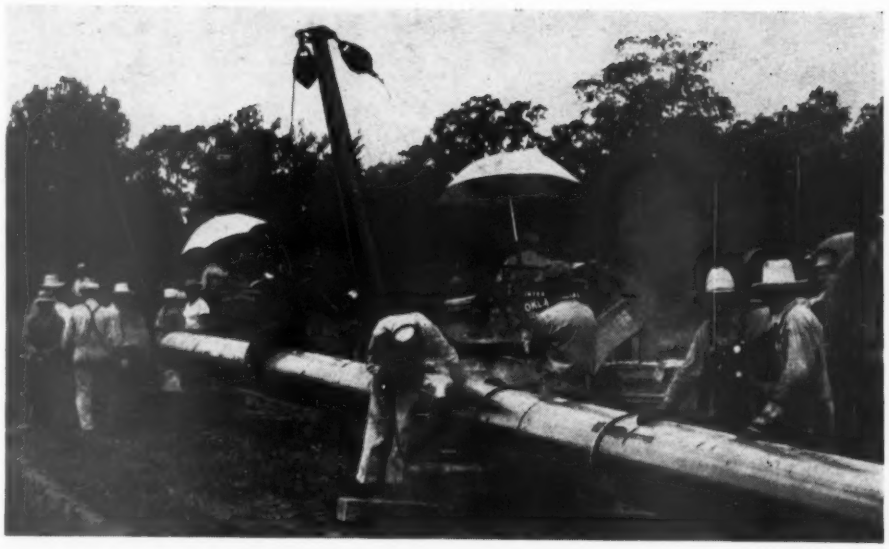
The line was laid of 20-in. diam pipe, which came in random lengths of 40 to 52 ft. Wall thickness on river crossings was ½ in. and on the rest of the line 5/16 in. Three beads were run on the 5/16 in. pipe joints and one or more additional beads on the ½-in. pipe. The line was coated and wrapped throughout, coal tar enamel being applied to a thickness of approximately 5/32 in. and wrapped with glass fiber or asbestos felt. In corrosive areas both types of wrapper were used. The pipe was cradled into the ditch behind the coating and wrapping machines. During hot weather the coating was sprayed with water over the ditch, so that the coating would harden before being lowered in; also, water running off the pipe

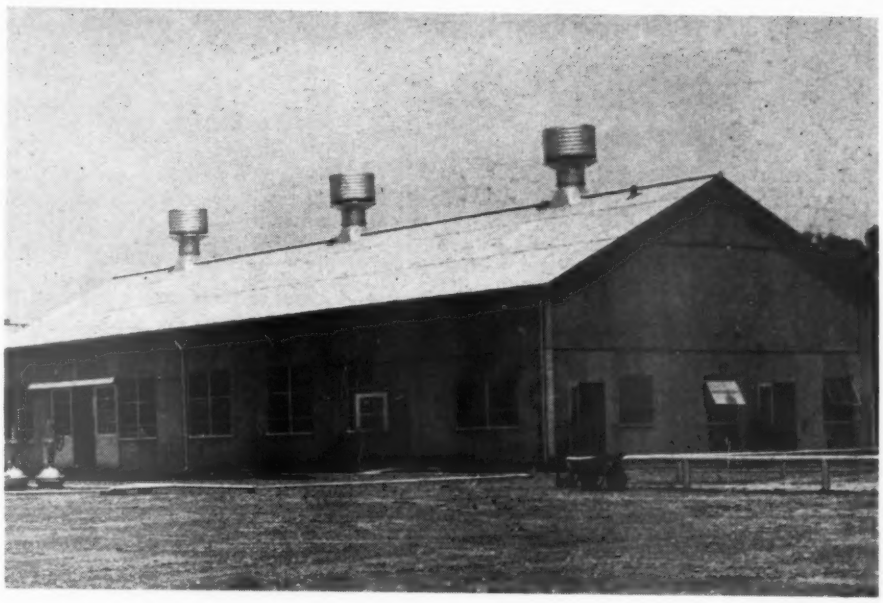
**The pipe line was coated and wrapped throughout. Coal tar enamel was applied to a thickness of 5/32 in. and wrapped with glass fiber or asbestos felt. The operation is shown above. Below is pictured an interesting part of the construction work, that of laying river crossings. This view shows the pipe, which has been coated, wrapped, and slatted, ready to be pulled across river.**

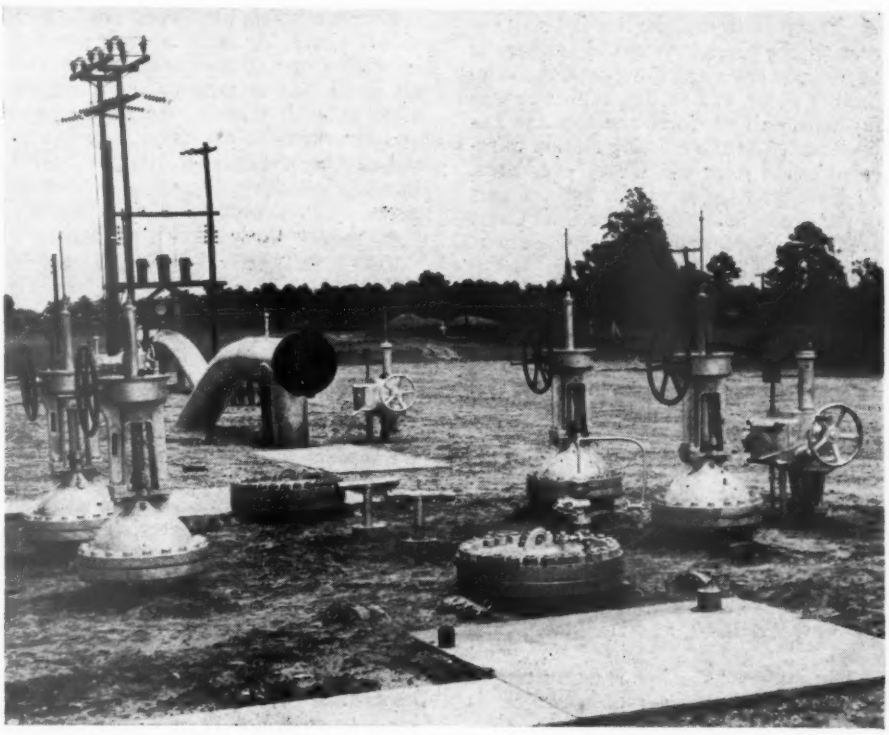
**Except for river crossings, wall thickness of the pipe was 5/16 in. In welding the joints, three beads were run.**

**Pump stations, like center photo, were constructed at Foreman and Conway, Arkansas, and Doniphan, Missouri, and equivalent equipment added at Corsicana, Texas, and Patoka, Illinois.**

**Scraper traps and motor-operated gate valves at the Foreman station, bottom, which is typical of other new stations.**







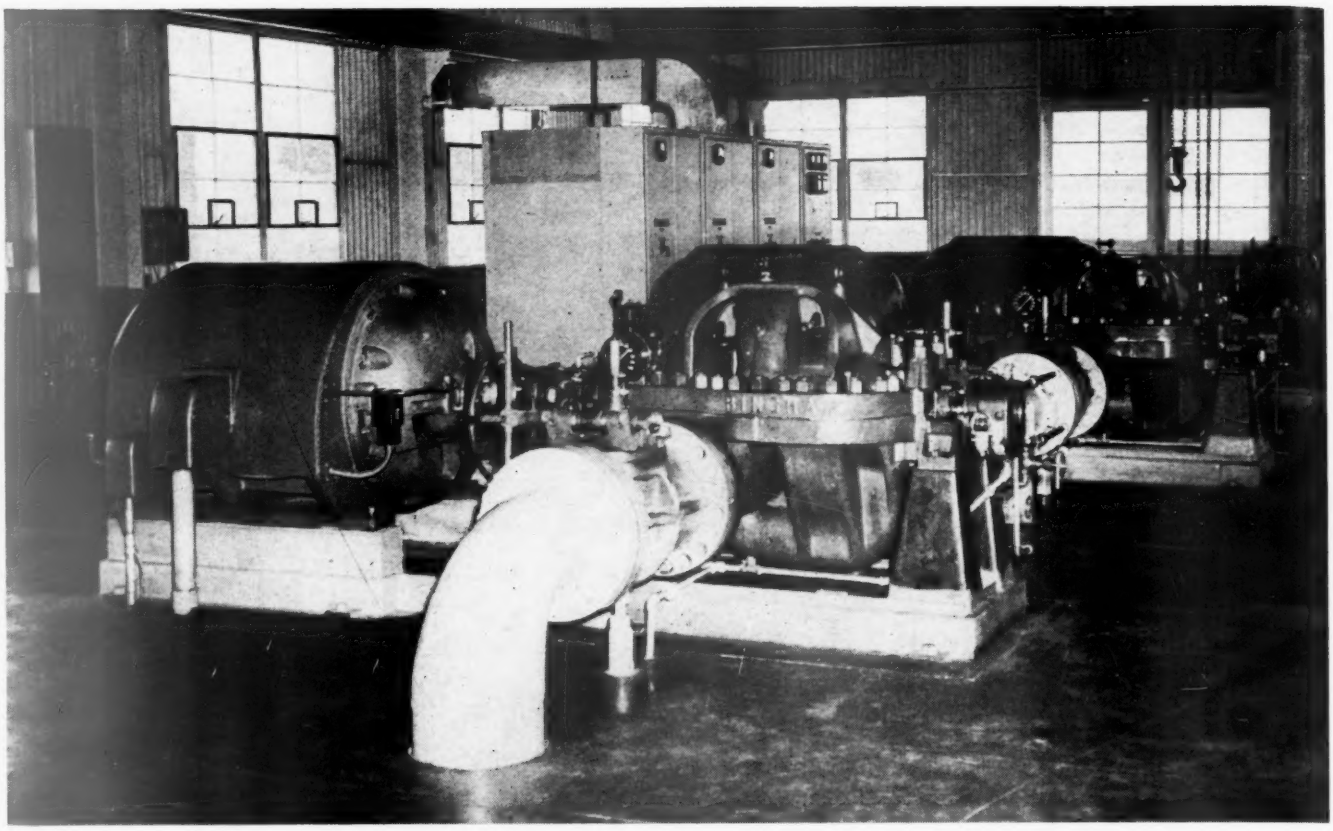
would wet the bottom of the ditch and keep the pipe cool while being backfilled. **A minimum cover of 16 in. was** provided.

● **River crossings.** An interesting part of the work was the laying of several major river crossings, and even some of the smaller crossings were not without their features. The four major crossings were the Red River, Arkansas, White, and Mississippi. The Red River was crossed near Foreman, Arkansas. The 20-in. diam ½-in. wall pipe was cased with 24-in. diam 5/16-in. wall pipe and the annular space filled with coal tar enamel. The crossing including approaches was 6200 ft wide, 500 ft being water. To excavate for the pipe a coffer dam was constructed half way across the river to divert the stream. Well points were used to dehydrate the sand and draglines employed to make the ditch. When pipe had been laid across half the river, the coffer dam was removed and one built for the second half and the same procedure followed. The pipe was made up in four-joint sections and pulled into place after the ditch had been made. The pipe was buried 6 ft below the bed of the river, as, incidentally, were all river crossings. No river clamps were used.

A somewhat different construction procedure was followed in making the Arkansas River crossing near Roland, Arkansas. The river was dredged and the pipe after being made up in sections was pulled into place. Draglines were employed to ditch the approaches. River clamps weighing 1000 lb each were spaced 20 ft apart. The pipe was not cased; however, it was coated with coal tar enamel, wrapped with both glass fiber and asbestos felt, after which it was lathed, then a flood coating applied over the lath. The overall crossing was 5007 ft wide and the water crossing 900 ft.

The White River crossing was made in the same manner at the Arkansas River. This crossing was 1500 ft overall with 700 ft of water.

The widest crossing was made of the Mississippi River insofar as the water crossing was concerned, although the overall width was not so great as some of the others. The water crossing was 2600 ft and the overall crossing 4300 ft. The pipe in this instance was laid from a barge after the river had been dredged. On the north side of the river



**Prime movers at new stations and at Corsicana consist of 900-hp motors driving centrifugal pumps. Motors have low starting torque with 96.5 efficiency rating.**

it was necessary to drill and shoot a rock ledge to make a channel for the pipe.

In addition to these crossings there were smaller crossings such as Little River, Ouachita River, St. Francis and many others. These were all cased and the annular space filled with coal tar enamel.

● **Pump stations.** The line is being operated as a closed system, thus there is no tankage except at Corsicana, the originating point, and at Patoka, the receiving terminal. At Corsicana tankage has been added at the existing station to receive crude from the West Texas area. At Corsicana the stream is split, a part of the crude being set to the Gulf Coast area through Magnolia's lines and a part entering the new line to Illinois. At Patoka the new line ties into present facilities going to Lima, Ohio, Salem, Illinois, and East St. Louis, Illinois. At the Patoka terminal nine 80,000 bbl and two 120,000 bbl tanks have been added.

Three new stations have been constructed and the equivalent of new stations added at Corsicana and Patoka on existing station sites. At all points except Patoka the prime movers are three 900-hp motors each driving a centrifugal pump. At Patoka the three pumps are driven by 525-hp diesel engines. The new stations are at Foreman, Arkansas; Conway, Arkansas, and Doniphan, Missouri.

The motors have low starting torque with 96.5 efficiency rating, which is equal to any synchronous motor. Electric power for operating the motors is purchased. At Patoka, which is a diesel-powered station, a 100-kw generator is mounted on the engine stubshaft between the engine and gear increaser on the pump to generate power for auxiliary equipment, including suction booster pumps, lights, air compressor, fuel oil centrifuge machines, etc.

Safety controls have been amply provided in keeping with modern practice in station operation. These include two air controlled emergency shutdown devices at each station, one in the yard and the other in the office, which consist of a manually operated pushbutton trip to shut down the entire station in cases of emergency. Other automatic controls are those governing high and low line pressures, motor bearing and stator temperatures, lube oil pressure, overspeed, etc.

All stations are equipped with two strainers. Both are on the incoming line and in most instances are used alternately, one being in use while the other is being cleaned. Also at each station are scraper traps for incoming and outgoing scrapers.

The main station building is constructed of transite on steel frame. The new pumping stations consist of main building, warehouse, office, and a cottage for the chief engineer. Ventilators are provided to keep the building free of any obnoxious or dangerous fumes, and starting panels are enclosed and kept under pressure to prevent gas leaking into controls.

● **Company supervisors.** For Magnolia Pipe Line Company J. E. McGeath supervised the overall construction program, with headquarters at Little Rock, Arkansas. George T. Jackson was in charge of pipe line construction, Stanley Westlake was in charge of station construction and operations during the starting up and testing of the line. D. H. Levy supervised electrical and communications installations.

The engineering for the line and stations was under the supervision of J. G. Norton. Coordination of all phases of the project was under the supervision of A. T. Glover, general superintendent at Dallas.

● **Contractors.** Four contractors participated in the line's construction. Oklahoma Contracting Company laid the line from Winfield, Texas, to Corsicana, Texas, from Patoka to Piedmont, Missouri, except for the Mississippi River crossing near Chester, Illinois, and from Doniphan, Missouri, to Conway, Arkansas, a total of 383 miles. H. C. Price Company constructed the line from Murfreesboro, Arkansas, to Conway, Arkansas, a distance of 112.5 miles; Eastern Construction Company from Winfield, Texas, to Murfreesboro, Arkansas, a distance of 108 miles, and O. C. Whitaker Company from Piedmont, Missouri, to Doniphan, Missouri, a distance of 40 miles. Crossings of the Arkansas, White, and Mississippi rivers were made by the Omaha Dredge and Dock Company and the Red River by Oklahoma Contracting Company. ★ ★ ★

# Hydrocarbon absorption and fractionation process design methods

## *Part 13. Plate-to-Plate Multicomponent Fractionation Calculation Methods*

By WAYNE C. EDMISTER*

IN THE previous installment (Part 12, *Petroleum Engineer*, April 1948) the preliminary steps involved in all multicomponent fractionation process design methods were discussed and illustrated. These steps determine preliminary values for the terminal conditions, i.e., temperatures, quantities and compositions, for the enriching and stripping sections so the theoretical plate and component distribution calculations may be made. Many methods for the latter calculations have been proposed. A list of 29 references were given at the end of Part 12 on this subject. Many of these methods will be covered in this series. The current installment is devoted to the rigorous plate-to-plate methods.

EXCLUSIVE

Three methods of making plate-to-plate component distribution calculations for multicomponent fractionation will be discussed, namely the procedures proposed by Lewis-Matheson, Thiele-Geddes, and Hummel. These three calculation methods differ in the step-by-step procedure, but have the following features in common: (a) assumptions, both *primary* and *secondary*, must be made, checked and revised; (b) component distribution calculations are made for each plate, starting at top and bottom of the fractionator and working toward the feed plate where the enriching and stripping calculations are meshed together; (c) the theoretical equilibrium plate concept is employed; (d) component material balances plus vapor-liquid equilibrium constitute the mechanism of going from plate-to-plate; and (e) heat balances are used to determine variations in the L/V ratio throughout the column.

The equations and calculation procedures described below for these three methods apply to the operation of the apparatus shown in Fig. 39 of Part 10 as a multicomponent fractionator. Enriching section plates are numbered from top down to plate "n," the plate above the feed, with any plate in the enriching section being designated by the subscript "i." Stripping section plates are numbered from bottom up to plate "m," the feed plate, with any plate in the enriching section being designated by the subscript "j." Where different reboiling and condensing arrangements are used than those shown in Fig. 39, these methods are valid and may be applied with only slight modifications in the equations.

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The Thiele-Geddes method employs mol fractions, while component mol quantities are used in the other two methods. Mol fractions in liquid and vapor streams are designated by "x" and "y", with the appropriate subscripts to define location. Component mol quantities in liquid and vapor are designated by "$l$" and "v", with the appropriate subscripts to define location. Total liquid and vapor quantities are designated by $L=\Sigma l$; $V=\Sigma v$. The products are $D=\Sigma d$ and $B=\Sigma b$.

It is more convenient to use component mol quantities than mol fractions. Where possible, it is preferable to use relative volatilities rather than vapor-liquid equilibrium ratios. One of these methods, the Lewis-Matheson method, possesses both of these advantages. However, the Lewis-Matheson has the disadvantage of starting with known product compositions, which is more troublesome the more components that appear in both products.

### LEWIS-MATHESON METHOD

In 1932 these authors showed how material balance and vapor-liquid equilibrium relationships could be combined in calculating from one equilibrium stage to the next and find the changes in compositions for multicomponent systems, thus employing the same basic principles that had already been in use for binary mixtures. In the original presentation, vapor-liquid equilibrium was found from vapor and total pressures, which is satisfactory where the mixture concerned obeys Raoult's law. Where the mixtures do not follow ideal gas or ideal mixture laws, the same procedure may be employed with the proper phase equilibrium ratios.

The plate-to-plate calculation method presented here as the "Lewis-Matheson" method does not resemble the original in many of the details, yet the fundamentals are the same. The important contribution made by these authors was to demonstrate that plate-to-plate calculations of this kind could be made for multicomponent systems by applying the same fundamental relationship that had previously been used for binary systems. This application involved meshing the enriching and stripping section calculations. Lewis and Matheson were probably the first to demonstrate how this feed plate meshing is done for multi-component fractionation calculations.

The Lewis-Matheson method is usually applied when the desired products are given and the problem is to find the required reflux ratio and number of theoretical plates. In applying this method, it is necessary to assume the reflux ratio. With the products and reflux ratio as the starting points, the number of theoretical plates are obtained.

In applying the Lewis-Matheson method, it is necessary to start with the distillate and bottoms products, at the condenser and reboiler, respectively, and work toward the feed plate by a combination of vapor-liquid equilibrium and material balance calculations on each theoretical plate. This is the weakness of this method. In order for the calculations to come out right, the amounts of each component in both products must be known correctly. This information is not usually known.

Frequently, there are only two or maybe three components that appear in both products. Components that appear in both products are called 'distributed" components. Those that appear in only one product are "non-distributed" components. The amounts of each distributed component in both products are obviously related. Since this information is required to start plate-to-plate calculations, it is necessary to estimate or assume the amounts of these distributed components in each product.

Theoretically, the proper amounts of the "nondistributed" components should be added to the terminal products so that these components would be present in the correct amounts when the feed plate is reached. The addition of these non-distributed components at the beginning is impractical because of the very low amounts that would be involved. Accordingly, the accepted procedure is to introduce these non-distributed components at intermediate points between the condenser (or reboiler) and the feed plate. In the enriching section, the non-distributed components are the higher boiling constituents of the feed that do not appear in the distillate. Likewise, in the stripping section, the non-distributed components are the lower boiling constituents of the feed that do not appear in the bottoms products.

In making plate-to-plate calculations, from each end toward the feed plate, the temperature on each plate is found by successive approximations. This offers no difficulty as long as the proper amounts of the non-distributed components are introduced at the right point. Otherwise, temperatures will not be cor-

rect near the feed plate and the enriching and stripping results will not match.

The equations, procedure and example given below for the "Lewis-Matheson" method employ relative volatilities ($\alpha = K/K_r$) rather than equilibrium constants ($K = y/x$) in the calculations. The use of $\alpha$ rather than K has the advantage of making the calculations almost independent of temperature. The relative volatility for a given component is close to the same value at all points, whereas the K constant increases with temperature. With relative volatilities, the plate-to-plate calculation for a multicomponent system is the same as those given in Part 11 (Table 54, Example 26) for a binary system.

*Procedure:* For this plate-to-plate method, the equations, by means of which calculations are made from one plate to another, are simple relationships expressing the equilibrium and material balance conditions. The relations are the same as those given in Table 54 in the solution of Eample 26 in Part 10. For convenience, these equations will be repeated here with an additional equation for checking the temperature. Each of these relations follows from the definitions of the terms.

In the enriching section, the calculations for one stage start with the vapor leaving a given plate and find, in order, the liquid leaving the same plate and the vapor leaving the plate below. In the stripping section, the calculations for one stage start with the liquid leaving a given plate and find, in order, the vapor leaving the same plate and the liquid leaving the plate above. This is the procedure followed in Table 54 for the two-component example.

With relative volatilities and component mol quantities the equilibrium calculations involve using the K ($= y/x$) relation for the key or reference component to check the assumed temperatures, or, if the $\alpha$ values are constant and do not change with temperature the value of $K_r$ (subscript r indicates reference component) is used to find the temperature. Usually $\alpha$ varies slightly with temperature so the temperature is guessed closely enough to estimate $\alpha$ values and then the correct temperature is found as a result of the equilibrium calculation in a method outlined below.

The enriching section plate-to-plate calculations involve the following steps and equations for each equilibrium stage.

*Step 1.* Starting with the vapor leaving plate "i", which is $v_i$ for each component with a total of $V_i = \Sigma v_i$, and the relative volatilities, $\alpha_i$, for each component, referred to one as a reference component, find $v_i/\alpha_i$ and $\Sigma(v_i/\alpha_i)$. This step amounts to finding the dew point liquid.

*Step 2.* The equilibrium constant of the reference component at this stage is

$$K_{ri} = \frac{\Sigma(v_i/\alpha_i)}{\Sigma v_i} \quad . \quad . \quad . \quad . \quad . \quad (101)$$

The temperature of plate "i" is found from the K values of the reference component.

*Step 3.* Knowing $\Sigma(v_i/\alpha_i)$ and the amount of reflux, compute the amount and composition of the liquid leaving this stage from

$$l_i = \frac{(v_i/\alpha_i)L_i}{\Sigma(v_i/\alpha_i)} \quad . \quad . \quad . \quad . \quad . \quad (102)$$

This step amounts to prorating the dew point liquid up to the total liquid leaving this plate.

*Step 4.* Find the vapor rising from the plate below to plate "i" from

$$v_i = l_i + d \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (103)$$

By means of equations 101, 102 and 103 calculations may be started at the condenser and carried plate-by-plate to the feed plate. The liquid overflow does not have to be constant as can be seen by equation 102. These same steps are repeated at each plate in the enriching section.

The stripping section plate-to-plate calculations involve the following steps and equations for each equilibrium stage.

*Step 1.* Starting with the liquid leaving plate "j", which is $l_j$ for each component with a total of $L_j = \Sigma l_j$, and the relative volatilities, $\alpha_i$, for each component, referred to one as reference component, find $\Sigma_j l_j$, and $\Sigma(\alpha_j l_j)$. This step amounts to finding the bubble point vapor.

*Step 2.* The equilibrium constant of the reference component at this stage is

$$K_{rj} = \frac{\Sigma l_j}{\Sigma(\alpha_j l_j)} \quad . \quad . \quad . \quad . \quad . \quad (104)$$

The temperature of plate "j" is found from the K values of the reference component.

*Step 3.* Knowing $\Sigma(\alpha_j l_j)$ and the amount of the boil-up vapor, compute the amount and composition of the vapor leaving this stage from

$$v_j = \frac{(\alpha_j l_j)V_j}{\Sigma(\alpha_j l_j)} \quad . \quad . \quad . \quad . \quad . \quad (105)$$

This step amounts to prorating the bub-

**TABLE 58. Stripping section plate-to-plate calculations for illustrating example by Lewis-Matheson method. (Example 27)**

Note: V = 83.9 mols for each plate

| | Reboiler; t=300 F | | | | Plate No. 1′; t=280 F | | | |
|---|---|---|---|---|---|---|---|---|
| | b | $\alpha$ | $\alpha b$ | $v_b$ | $l_1'$ | $\alpha$ | $\alpha l_1'$ | $v_1'$ |
| Methane | .. | .. | .. | .. | .. | .. | .. | .. |
| Ethane | .. | .. | .. | .. | .. | .. | .. | .. |
| Propane | 0.4 | 1.00 | 0.40 | 2.27 | 2.67 | 1.00 | 2.67 | 4.28 |
| Butane | 16.7 | 0.537 | 8.96 | 50.85 | 67.55 | 0.542 | 36.58 | 58.70 |
| Pentane | 11.0 | 0.296 | 3.26 | 18.50 | 29.50 | 0.300 | 9.00 | 14.44 |
| Hexane | 12.0 | 0.181 | 2.17 | 12.32 | 24.32 | 0.167 | 4.07 | 6.53 |
| Total | 40.1 | | 14.79 | 83.94 | 124.04 | | 52.32 | 83.95 |
| | Plate No. 2′; t=266 F | | | | Plate No. 3′; t=257 F | | | |
| | $l_2'$ | $\alpha$ | $\alpha l_2'$ | $v_2'$ | $l_3'$ | $\alpha$ | $\alpha l_3'$ | $v_3'$ |
| Methane | .. | .. | .. | .. | .. | .. | .. | .. |
| Ethane | .. | .. | .. | .. | .. | .. | .. | .. |
| Propane | 4.68 | 1.00 | 4.68 | 7.04 | 7.44 | 1.00 | 7.44 | 10.77 |
| Butane | 75.40 | 0.54 | 40.70 | 61.24 | 77.94 | 0.536 | 41.77 | 60.45 |
| Pentane | 25.44 | 0.29 | 7.39 | 11.12 | 22.12 | 0.280 | 6.20 | 8.98 |
| Hexane | 18.53 | 0.162 | 3.00 | 4.51 | 16.51 | 0.154 | 2.54 | 3.68 |
| Total | 124.05 | | 55.77 | 83.91 | 124.01 | | 57.95 | 83.88 |
| | Plate No. 4′; t=249 F | | | | Plate No. 5′; t=243 F | | | |
| | $l_4'$ | $\alpha$ | $\alpha l_4'$ | $v_4'$ | $l_5'$ | $\alpha$ | $\alpha l_5'$ | $v_5'$ |
| Methane | .. | .. | .. | .. | .. | .. | .. | .. |
| Ethane | .. | .. | .. | .. | .. | .. | .. | 0.05 |
| Propane | 11.17 | 1.00 | 11.17 | 15.64 | 16.04 | 1.00 | 16.04 | 21.56 |
| Butane | 77.15 | 0.532 | 41.03 | 57.40 | 74.10 | 0.530 | 39.28 | 52.80 |
| Propane | 19.98 | 0.273 | 5.46 | 7.64 | 18.64 | 0.270 | 5.04 | 6.78 |
| Hexane | 15.68 | 0.148 | 2.32 | 3.25 | 15.25 | 0.144 | 2.02 | 2.72 |
| Total | 123.98 | | 59.98 | 83.93 | 124.03 | | 62.38 | 83.91 |
| | Plate No. 6′; t=233 F | | | | Plate No. 7′; t=225 F | | | |
| | $l_6'$ | $\alpha$ | $\alpha l_6'$ | $v_6'$ | $l_7'$ | $\alpha$ | $\alpha l_7'$ | $v_7'$ |
| Methane | .. | .. | .. | .. | .. | .. | .. | 0.02 |
| Ethane | 0.05 | 2.46 | 0.12 | 0.16 | 0.16 | 2.45 | 0.39 | 0.48 |
| Propane | 21.96 | 1.00 | 21.96 | 28.10 | 28.50 | 1.00 | 28.50 | 34.74 |
| Butane | 69.50 | 0.53 | 36.80 | 47.10 | 63.80 | 0.527 | 33.60 | 40.95 |
| Pentane | 17.78 | 0.261 | 4.64 | 5.94 | 16.94 | 0.257 | 4.35 | 5.30 |
| Hexane | 14.72 | 0.138 | 2.03 | 2.60 | 14.60 | 0.135 | 1.97 | 2.40 |
| Total | 124.01 | | 65.55 | 83.90 | 124.00 | | 68.81 | 83.39 |
| | Plate No. 8′; t=215 F | | | | Plate No. 9′; t=205 F | | | |
| | $l_8'$ | $\alpha$ | $\alpha l_8'$ | $v_8'$ | $l_9'$ | $\alpha$ | $\alpha l_9'$ | $v_9'$ |
| Methane | 0.02 | 9.5 | 0.19 | 0.22 | 0.22 | 9.70 | 2.13 | 2.26 |
| Ethane | 0.48 | 2.46 | 1.18 | 1.37 | 1.37 | 2.47 | 3.38 | 3.58 |
| Propane | 35.14 | 1.00 | 35.14 | 40.70 | 41.10 | 1.00 | 41.10 | 43.70 |
| Butane | 57.65 | 0.521 | 30.00 | 34.77 | 51.47 | 0.520 | 26.80 | 28.50 |
| Pentane | 16.30 | 0.250 | 4.08 | 4.73 | 15.73 | 0.244 | 3.84 | 4.08 |
| Hexane | 14.40 | 0.128 | 1.84 | 2.13 | 14.13 | 0.122 | 1.72 | 1.83 |
| Total | 123.99 | | 72.43 | 83.92 | 124.05 | | 78.97 | 83.95 |

ble point vapor up to the total vapor leaving this plate.

*Step 4.* Find the liquid overflowing from the plate above to plate "j" from

$$l_{j+1} = v_j + b \quad . \quad . \quad . \quad . \quad . \quad . \quad (106)$$

By means of equations 104, 105 and 106 calculations may be started at the reboiler and carried plate-to-plate to the feed plate. The vapor up-flow may be different at each plate as can be seen by equation 105. These calculations are repeated at each plate in the stripping section.

Plate-to-plate calculations, made with the above equations, for both sections must be meshed at the feed plate to complete the design. In order to accomplish this meshing, all of the components of the feed must appear in the liquid form the enriching section and in the vapor from the stripping section. In many separations the distillate contains some light components that do not appear in the bottoms and, conversely, the bottoms contain some heavy components that do not appear in the distillate.

Where there are "non-distributed" components these components must be introduced in the proper amounts at some intermediate plate between the condenser (or reboiler) and the feed plate, the heavy "non distributed" components being added in the enriching calculations and the light "non-distributed" components being added in the stripping calculations. The amounts and points of addition of these non-distributed components are determined by trial. Of course, experience and judgment permit balancing the calculations in fewer trials. The introduction of these non-distributed components must be accomplished with the feed plate mesh in mind. Reference to the results of the feed plate calculations in Table 57 (Part 12) is necessary in this operation.

The amounts of the non-distributed components introduced and the theoretical plates on which they are added must be such that the values of $l_n$ and $v_m$ obtained in the plate-to-plate calculations agree with the values of $l_n$ and $v_m$ obtained in the feed plate calculation, as in Table 57.

The procedure for meshing the enriching and stripping section calculations will be illustrated in an example later. In brief, the procedure is to combine the values in $l_n$ and $v_m$ with the values of d and b to find the values of $v_f$ and $l_f$, the vapor and liquid portion of the feed, and then to compare with the values of $v_f$ and $l_f$ obtained from flashing the feed, as in Table 55. If a check is not obtained, the calculations must be repeated.

## THIELE-GEDDES METHOD

This method, which was published in 1933, is a rigorous plate-to-plate calculation method wherein the calculations are made in terms of mol fraction ratios (vapor or liquid to products) using vapor-liquid equilibrium ratios (K=y/x). In this method it is not necessary to know or assume the products. However, it is necessary to start with the number of equilibrium plates and reflux ratio. These constitute the *primary* assumptions involved in applying the Thiele-Geddes method. The *secondary* assumptions of the Thiele-Geddes method are the temperatures of the theoretical plates.

The procedure proposed by these authors is to calculate from condenser (and reboiler) to the feed plate by means of mol fraction ratios, using the mol fraction in the distillate as the denominator in the enriching section and the mol fraction in the bottoms product as the denominator in the stripping section. These ratios are meshed at the feed plate to find the products; after meshing it is possible to go back and calculate compositions on each plate and check the temperature assumptions. Temperatures cannot be checked until the calculations are finished for a given set of assumptions.

The equations required in applying this method are obtained by writing the equilibrium and material balance relationships in the proper way. In addition to the material balance and vapor-liquid equilibrium equations, relationships are required for checking temperatures on each theoretical plate and for meshing the enriching and stripping section calculations at the feed plate. These equations are more complicated than those for the Lewis Matheson method because of the use of mol fraction ratios rather than component molal quantities.

*Enriching section equations.* The enriching section equations for the Thiele-Geddes method are developed from equilibrium and component material balance considerations using mol fractions.

Equilibrium between vapor and liquid at any plate in the enriching section is

**TABLE 59. Enriching section plate-to-plate calculations for illustrating example by Lewis-Matheson method. (Example 27)**

Note: L=90 mols for each plate

| | Condenser: t=63 F | | | | Plate No. 1; t=105 F' | | | |
|---|---|---|---|---|---|---|---|---|
| | d | $\alpha$ | d/d | $l_d$ | $v_1$ | $\alpha$ | $v_1/\alpha$ | $l_1$ |
| Methane | 26.0 | 15.40 | 1.69 | 5.03 | 31.03 | 12.8 | 2.43 | 1.90 |
| Ethane | 9.0 | 3.00 | 3.00 | 8.94 | 17.94 | 2.7 | 6.65 | 5.21 |
| Propane | 24.6 | 1.00 | 24.60 | 73.30 | 97.90 | 1.00 | 97.90 | 76.60 |
| Butane | 0.3 | 0.32 | 0.94 | 2.79 | 3.09 | 0.39 | 7.93 | 6.21 |
| Pentane | .. | .. | .. | .. | .. | .. | .. | .. |
| Hexane | .. | .. | .. | .. | .. | .. | .. | .. |
| Total | 59.9 | | 30.23 | 90.06 | 149.96 | | 114.91 | 89.92 |

| | Plate No. 1; t=105 F | | | | Plate No. 3; t=123 F | | | |
|---|---|---|---|---|---|---|---|---|
| | $v_2$ | $\alpha$ | $v_2/\alpha$ | $l_2$ | $v_3$ | $\alpha$ | $v_3/\alpha$ | $l_3$ |
| Methane | 27.90 | 12.00 | 2.32 | 1.67 | 27.67 | 11.80 | 2.34 | 1.60 |
| Ethane | 14.21 | 2.62 | 5.42 | 3.90 | 12.90 | 2.60 | 4.96 | 3.38 |
| Propane | 101.20 | 1.00 | 101.20 | 72.90 | 97.50 | 1.00 | 97.50 | 66.50 |
| Butane | 6.51 | 0.42 | 15.50 | 11.16 | 11.46 | 0.43 | 26.68 | 18.20 |
| Pentane | .. | .. | .. | 0.07 | 0.07 | 0.165 | 0.42 | 0.29 |
| Hexane | .. | .. | .. | .. | .. | .. | .. | .. |
| Total | 149.80 | | 124.44 | 89.70 | 149.60 | | 131.90 | 89.97 |

| | Plate No. 4; t=132 F | | | | Plate No. 5; t=144 F | | | |
|---|---|---|---|---|---|---|---|---|
| | $v_4$ | $\alpha$ | $v_4/\alpha$ | $l_4$ | $v_5$ | $\alpha$ | $v_5/\alpha$ | $l_5$ |
| Methane | 27.60 | 11.50 | 2.40 | 1.52 | 27.52 | 11.10 | 2.48 | 1.43 |
| Ethane | 12.38 | 2.58 | 4.80 | 3.04 | 12.04 | 2.53 | 4.76 | 2.75 |
| Propane | 91.10 | 1.00 | 91.10 | 57.70 | 82.30 | 1.00 | 82.30 | 47.50 |
| Butane | 18.50 | 0.44 | 42.06 | 26.63 | 26.93 | 0.45 | 59.90 | 34.60 |
| Pentane | 0.29 | 0.175 | 1.66 | 1.05 | 1.05 | 0.186 | 5.64 | 3.25 |
| Hexane | | | | 0.08 | 0.08 | 0.077 | 1.04 | 0.60 |
| Total | 149.87 | | 142.02 | 90.02 | 149.92 | | 156.12 | 90.07 |

| | Plate No. 6; t=160 F | | | |
|---|---|---|---|---|
| | $v_6$ | $\alpha$ | $v_6/\alpha$ | $l_6$ |
| Methane | 27.43 | 10.5 | 2.61 | 1.34 |
| Ethane | 11.75 | 2.5 | 4.70 | 2.41 |
| Propane | 72.10 | 1.00 | 72.10 | 37.00 |
| Butane | 34.90 | 0.475 | 73.50 | 37.70 |
| Pentane | 3.25 | 0.205 | 15.85 | 8.13 |
| Hexane | 0.60 | 0.090 | 6.67 | 3.42 |
| Total | 150.03 | | 175.43 | 90.00 |

**TABLE 60. Feed plate mesh for Lewis-Matheson plate-to-plate calculations. (Example 27)**

| | Enriching | | Stripping | | Feed vapor | | Feed liquid | |
|---|---|---|---|---|---|---|---|---|
| | $l_n=l_6$ | $v_{n+1}=l_n+d$ | $v_n=v_{9'}$ | $l_{m+1}=v_m+b$ | $v_{n+1}-v_m$ | $v_f$ | $l_{m+j}-l_n$ | $l_f$ |
| Methane | 1.34 | 27.34 | 2.26 | 2.26 | 25.08 | 25.0 | 0.92 | 1.0 |
| Ethane | 2.41 | 11.41 | 3.58 | 3.58 | 7.83 | 8.0 | 1.17 | 1.0 |
| Propane | 37.00 | 61.60 | 43.70 | 44.10 | 17.90 | 18.0 | 7.10 | 7.0 |
| Butane | 37.70 | 38.00 | 28.50 | 45.20 | 9.50 | 9.0 | 7.50 | 8.0 |
| Pentane | 8.13 | 8.13 | 4.08 | 15.08 | 4.05 | 4.0 | 6.95 | 7.0 |
| Hexane | 3.42 | 3.42 | 1.83 | 13.83 | 1.59 | 2.0 | 10.41 | 10.0 |
| Total | 90.00 | 149.90 | 83.95 | 124.05 | 65.95 | 66.0 | 34.05 | 34.0 |

expressed by rearranging the definition of K (i.e.=y/x) and dividing both sides by $y_d$ to give the following:

$$\frac{x_i}{y_d} = \frac{1}{K_i}\left(\frac{y_i}{y_d}\right) \quad . \quad . \quad . \quad . \quad (107)$$

Equation 107 permits finding the liquid leaving a theoretical plate from the vapor leaving the same equilibrium stage. At the condenser $y_i = y_d$ and equation 107 becomes $x_d/y_d = 1/K_d$.

A component material balance around the condenser and upper portion of the enriching section and including plate "i" gives

$$V_{i+1}y_{i+1} = L_i x_i + Dy_d \quad . \quad . \quad . \quad (108)$$

Where: $L_i$ and $V_{i+1}$ are the total molal liquid and vapor quantities at the point in question, i.e. between plate "i" and plate "i + 1"; D is the mols of total distillate; and $y_{i+1}$, $x_d$ and $y_d$ are mol fractions.

By total material balance, $V_{i+1} = L_i + D$. Combining this total material balance with equation 108 to eliminate D and dividing through by $V_{i+1}y_d$, give the following component material balance relationship

$$\frac{y_{i+1}}{y_d} = \frac{L_i}{V_{i+1}}\left[\frac{x_i}{y_d} - 1\right] + 1 \quad . \quad (109)$$

Equation 109 permits going from the liquid leaving plate "i" to the vapor leaving the plate below, i.e. "i + 1. This equation, like equation 107, uses mol fraction ratios.

*Stripping section equations.* The stripping section equations for the Thiele-Geddes method are developed in similar manner the enriching section equations were developed above.

Equilibrium between vapor and liquid at any plate in the stripping section is expressed by rearranging the definition of K and dividing both sides by $x_b$, to give the following:

$$\frac{y_j}{x_b} = K_j\left(\frac{x_j}{x_b}\right) \quad . \quad . \quad . \quad . \quad . \quad (110)$$

Equation 110 permits going from the liquid to the equilibrium vapor leaving the same plate. At the reboiler $x_i = x_b$ and equation 110 becomes $y_b/x_b = K_b$.

A component material balance around the reboiler and the lower portion of the stripping section and including plate "j" gives

$$L_{j+1}x_{j+1} = V_j y_j + Bx_b \quad . \quad . \quad . \quad (111)$$

Where: $L_{j+1}$ and $V_j$ are the total molal liquid and vapor quantities at the point in question; i.e., between plate "j" and plate "j + 1"; B is the mols of total bottoms product; and $x_{j+1}$, $y_j$, and $x_b$ are mol fractions.

By total material balance $L_{j+1} = V_j + B$. Combining this total material balance with equation 111 to eliminate B and dividing by $L_{j+1}x_b$, gives the following component material balance relationship

$$\frac{X_{j+1}}{x_b} = \frac{V_j}{L_{j+1}}\left[\frac{y_j}{x_b} - 1\right] + 1 \quad . \quad (112)$$

Equation 112 permits going from the vapor leaving plate "j" to the liquid, leaving the plate above, i.e. "J + 1". This equation, like equations 107, 109 and 110 uses mol fraction ratios.

*Feed plate mesh.* The enriching and stripping section calculations must be meshed at the feed plate to compute the distillate and bottoms products. Feed condition, whether liquid, vapor or vapor and liquid, must be taken into consideration in making these calculations. If the feed is liquid at its boiling point or vapor at its dew point the calculations are more simple than when the feed is partially vaporized.

In setting the L/V and V/L ratios for the plate-to-plate calculations, the phase condition of the feed must be taken into consideration also but this is done by over-all heat and material balances starting with either the condenser or reboiler to find consistent L and V quantities in different sections. The feed plate mesh involves a more detailed consideration of the phase condition of the feed. In other words, the amounts of the individual components in the vapor and liquid portions of the flashed feed are involved.

In making this feed plate mesh calculation, it is necessary to know or assume the ratio of distillate to bottoms product D/B. This is an auxiliary assumption that is checked after the products are calculated and before the plate temperatures are checked.

From plate-to-plate calculations by the Thiele-Geddes method for the enriching and stripping sections the following ratios are found by applying the above equations in the manner outlined later.

$\frac{y_{n+1}}{y_d}$ and $\frac{x_n}{y_d}$; for enriching section

$\frac{y_m}{x_b}$ and $\frac{x_{m+1}}{x_b}$; for stripping section

From these ratios it is desired to find the ratio $y_d/x_b$.

If the feed is saturated liquid, i.e., 100 per cent liquid at its boiling point $y_{n+1} = y_m$ and

$$\frac{y_d}{x_b} = \frac{(y_m/x_b)}{(y_{n+1}/y_d)} \quad . \quad . \quad . \quad . \quad . \quad (113)$$

If the feed is saturated vapor, i.e. 100 per cent vapor at the dew point

$x_n = x_{m+1}$ and

$$\frac{y_d}{x_b} = \frac{(x_{n+1}/x_b)}{(x_n/y_d)} \quad . \quad . \quad . \quad . \quad . \quad (114)$$

The ratio $y_d/x_b$ is used, found for each component from either equation 113 or 114.

Over-all material balance on the system is written

**TABLE 61**

## SUMMARY OF THIELE-GEDDES METHOD

Plate-to-plate calculation procedure, working with composition ratios and computing products for assumed plates and reflux.

*Assumptions:*

Primary—number of theoretical plates and heat input or reflux.

Secondary—temperature on each plate.

*Procedure:*

1. Set up calculation form with columns for each tray.
2. Carry through plate-to-plate calculations from reflux condenser and from reboiler to feed plate.
3. Mesh results at feed plate and compute distillate and bottoms.
4. With product compositions, go back and check assumed temperatures.
5. Adjust temperatures and repeat. When temperatures are correct $\Sigma DX_i = D$ and $\Sigma BY_j = B$ on each plate.

*Equations and form:*

| Each plate of enriching section | | | | Feed plate mesh | | | | | Each plate of stripping section | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Component | $K_i$ | $X_i/X_d$ | $DX_i$ | $Y_{i+1}/X_d$ | $\frac{X_d}{X_b} = \frac{Y/X_b}{Y/X_d}$ | $\frac{D}{B}\left(\frac{X_d}{X_b}\right)$ | $BX_b$ | $FX_f$ | $DX_d$ | $K_j$ | $Y_j/X_b$ | $BY_j$ | $X_{j+1}/X_b$ |
| $C_1$ | | | | $\frac{Y_{i+1}}{X_d} = \frac{L}{V}\left(\frac{X_i}{X_d} - 1\right) + 1$ | | | $BX_b = \frac{FX_f}{\frac{D}{B}\left(\frac{X_d}{X_b}\right) + 1}$ | | | | | | $\frac{X_{j+1}}{X_b} = \frac{V}{L}\left(\frac{Y_j}{X_b} - 1\right) + 1$ |
| $C_2$ | | | | | | | | | | | | | |
| $C_3$ | | | | | | | | | | | | | |
| Etc. | | | | | | | | | $DX_d = FX_f - BX_b$ | | | | |

*Note:* Feed plate equation for feed at boiling point.

$$Fz = Dy_d + Bx_b \quad . \quad . \quad . \quad . \quad . \quad (115)$$

Where: Z is the mol fraction of component in feed. From equation 115 by rearrangement, it follows that

$$Bx_b = \frac{Fz}{\frac{D}{B}\left(\frac{y_d}{x_b}\right)+1} \quad . \quad . \quad . \quad (116)$$

When the feed is either saturated liquid or saturated vapor and not mixed vapor and liquid, equation 116 may be used to find the bottoms product from feed composition and the two ratios, $y_d/x_b$, for each component, and D/B for the total products. The distillate product is then readily found from the feed and bottoms by means of equation 115.

Alternately, the distillate may be found directly from the following equation, obtained by rearranging equation 115:

$$Dy_d = \frac{Fz}{\frac{B}{D}\left(\frac{x_b}{y_d}\right)+1} \quad . \quad . \quad . \quad (117)$$

In applying equations 116 or 117, the ratios of $y_b/x_b$ is found from equation 113 or 114, depending upon the condition of the feed.

If the feed is mixed vapor and liquid, it is necessary to use another and more complete equation instead of equation 116 or 117. This equation is derived from a component material balance at the point where the feed vapors and liquid mix with the vapors and liquids to and from the enriching and stripping sections, which states.

$$y_{n+l}(V_m+V_f) = V_f y_f + V_m y_m \quad . \quad (118)$$

Combining equations 118 and 115 and rearranging gives

$$Bx_b = \frac{Fz - \left[\left(\frac{D}{V_m+V_f}\right)\left(\frac{V_f y_f}{y_{n+1}/y_d}\right)\right]}{\left[\frac{D}{B}\left(\frac{V_m}{V_m+V_f}\right)\left(\frac{y_m/x_b}{y_{n+1}/y_d}\right)\right]+1} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (119)$$

When $V_f$ and $y_f$ are zero, as is the case for all liquid feed, equation 119 reduces to equation 116. Equation 119 would not be used for vapor feed. A similar equation could be derived, however. It is more convenient to use equation 116 with equations 113 or 114 for all liquid or all vapor feed.

*Temperature check.* After the feed plate mesh calculations are completed and values of $Dy_d$ and $Bx_b$ have been computed for all components, the temperatures that were assumed on each plate may be checked. In the enriching section this is accomplished by the finding $Dx_i$ from

$$Dx_i = \left(\frac{x_i}{y_d}\right) Dy_d \quad . \quad . \quad . \quad . \quad (120)$$

At the correct temperature

$$\Sigma(Dx_i) = D \quad . \quad . \quad . \quad . \quad . \quad . \quad (121)$$

In the stripping section the computations are

$$By_j = \left(\frac{y_j}{x_b}\right) Bx_b \quad . \quad . \quad . \quad (122)$$

and

$$\Sigma(By_j) = B \quad . \quad . \quad . \quad . \quad . \quad . \quad (123)$$

If the assumed temperatures are not correct, as determined by the summations shown in equations 121 and 123, new temperatures must be assumed and the entire calculation repeated. Incorrect temperatures at any point will invalidate all of the calculations.

## HUMMEL METHOD

This method was published in 1944. It is similar to the Thiele-Geddes method in that the products are computed for a given number of equilibrium stages and reflux quantity. Instead of mol fraction ratios the Hummel method employs ratios of component mol quantities. Another feature is the use of the factors L/KV and KV/L which are known as the *absorption* and *stripping* factors.

In the Hummel method, the temperature gradient is estimated from plate-to-plate computations at the ends of each section (i.e., enriching and stripping). These preliminary calculations are started in the manner illustrated in Tables 55 and 57 of Part 12. With a few temperatures established in this way, the equilibrium ratio, $K_r$, for the reference component is plotted against the number of plates and this curve used as the basis for computing L/KV and KV/L factors for other components from the values for the reference component.

Unlike the two previously described plate-to-plate methods, the individual plate temperatures are not checked in the Hummel method. Instead of the entire temperature gradient is checked at once in making the feed plate mesh calculations. If the results do not mesh properly a new gradient must be established and the calculations repeated.

*Equations.* The equations used in this method are likewise obtained from component material balance and vapor liquid equilibrium relationships. There is

**TABLE 62. Stripping section plate-to-plate calculations for illustrating example by Thiele-Geddes method. (Example 28)**

Note: $\frac{V}{L}$ = 0.677 for each plate

| | Reboiler; t=300 F | | | | Plate No. 1'; t=280 F | | | |
|---|---|---|---|---|---|---|---|---|
| | $K_b$ | $y_b/x_b$ | $By_b$ | $K1'/x_b$ | $K_1'$ | $y1'/x_b$ | $By_1'$ | $K2'/x_b$ |
| Methane | 21.7 | 21.7 | 0 | 15.00 | 20.5 | 307.5 | 0 | 208.5 |
| Ethane | 6.4 | 6.4 | 0 | 4.65 | 5.8 | 27.0 | 0 | 18.6 |
| Propane | 2.7 | 2.7 | 1.08 | 2.15 | 2.4 | 5.16 | 2.06 | 3.82 |
| Butane | 1.45 | 1.45 | 24.20 | 1.305 | 1.3 | 1.70 | 28.40 | 1.474 |
| Pentane | 0.82 | 0.82 | 9.02 | 0.88 | 0.72 | 0.633 | 6.96 | 0.752 |
| Hexane | 0.49 | 0.49 | 5.88 | 0.655 | 0.40 | 0.262 | 3.145 | 0.500 |
| Total | | | 40.18 | | | | 40.565 | |

| | Plate No. 2'; t=266 F | | | | Plate No 3'; t=257 F | | | |
|---|---|---|---|---|---|---|---|---|
| | $K_2'$ | $y1'/x_6$ | $By_1'$ | $y2'/x_b$ | $K_2'$ | $y2'/x_b$ | $By_3'$ | $y4'/x6$ |
| Methane | 19.5 | 4070 | .. | 2760 | 19.0 | 52,500 | 0 | 35,500 |
| Ethane | 5.47 | 101.8 | .. | 69.2 | 5.24 | 362.5 | 0 | 246.5 |
| Propane | 2.24 | 8.55 | 3.42 | 6.11 | 2.14 | 13.10 | 5.24 | 9.19 |
| Butane | 1.21 | 1.785 | 29.80 | 1.532 | 1.15 | 1.762 | 29.42 | 1.5155 |
| Pentane | 0.65 | 0.488 | 5.37 | 0.653 | 0.602 | 0.392 | 4.31 | 0.589 |
| Hexane | 0.359 | 0.1795 | 2.155 | 0.445 | 0 332 | 0.148 | 1.78 | 0.425 |
| Total | | | 40.745 | | | | 40.75 | |

| | Plate No. 4'; t=249 F | | | | Plate No. 5'; t=243 F | | | |
|---|---|---|---|---|---|---|---|---|
| | $K_4'$ | $y4'/x_b$ | $By_4'$ | $x5'/x_b$ | $K_5'$ | $y5'/x_6'$ | $By_5'$ | $x6'/x_b$ |
| Methane | 18.54 | $6.6x10^5$ | 0 | $4.46x10^5$ | 18.2 | $8.1x10^6$ | 0 | $5.49x10^6$ |
| Ethane | 5.05 | 1248 | 0.007 | 843.0 | 4.91 | 4140 | 0.024 | 2805 |
| Propane | 2.06 | 18.92 | 7.665 | 13.12 | 2.00 | 26.24 | 10.500 | 18.1 |
| Butane | 1.10 | 1.667 | 27.830 | 1.451 | 1.064 | 1.546 | 25.820 | 1.37 |
| Pentane | 0.583 | 0.343 | 3.775 | 0.555 | 0.542 | 0.301 | 3.310 | 0.526 |
| Hexane | 0.321 | 0.1365 | 1.64 | 0.416 | 0.292 | 0.1215 | 1.460 | 0.405 |
| Total | | | 39.917 | | | | 41.114 | |

| | Plate No. 6'; t=233 F | | | | Plate No. 7; t=225 F' | | | |
|---|---|---|---|---|---|---|---|---|
| | $K_6'$ | $y6'/x_b$ | $By_6'$ | $x7'/x_6$ | $K_7'$ | $y7'/xb$ | $By_7'$ | $x7'/x_6$ |
| Methane | 17.30 | $9.5x10^7$ | 0.001 | $6.44x10^7$ | 16.85 | $10.84x10^8$ | 0.01 | $7.3x10^8$ |
| Ethane | 4.63 | 13,000 | 0.074 | $8.8x10^5$ | 4.45 | $3.92x10^4$ | 0.20 | $2.65x10^4$ |
| Propane | 1.88 | 34.0 | 13.60 | 23.35 | 1.80 | 42.00 | 16.80 | 28.75 |
| Butane | 0.996 | 1.365 | 22.800 | 1.2475 | 0.95 | 1.185 | 19.79 | 1.125 |
| Pentane | 0.494 | 0.260 | 2.860 | 0.499 | 0.465 | 0.232 | 2.55 | 0.481 |
| Hexane | 0.263 | 0.1066 | 1.280 | 0.395 | 0.243 | 0.096 | 1.15 | 0.388 |
| Total | | | 40.615 | | | | 40.50 | |

| | Plate No. 8'; t=215 F | | | | Plate No. 9'; t=205 F | | | |
|---|---|---|---|---|---|---|---|---|
| | $K_8'$ | $y8'/x_6$ | $By_8'$ | $x9'/x_b$ | $K_9'$ | $y_m/x_b$ | $By_9'$ | |
| Methane | 16.05 | $11.8x10^9$ | 0.11 | $8.0x10^9$ | 15.0 | $12.0x10^{10}$ | 1.10 | |
| Ethane | 4.18 | $11.1x10^4$ | 0.63 | $7.5x10^4$ | 3.8 | $2.85x10^5$ | 1.63 | |
| Propane | 1.69 | 48.50 | 19.40 | 33.20 | 1.58 | 52.4 | 20.95 | |
| Butane | 0.88 | 0.99 | 16.53 | 0.993 | 0.80 | 0.794 | 13.26 | |
| Pentane | 0.423 | 0.2035 | 2.24 | 0.493 | 0.38 | 0.1874 | 2.06 | |
| Hexane | 0.217 | 0.0843 | 1.01 | 0.380 | 0.19 | 0.0722 | 0.87 | |
| Total | | | 39.92 | | | | 39.87 | |

one equation for the enriching section and one for the stripping section.

A component material balance around the top part of the fractionator is written:

$$v_{i+1} = l_i + d \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (103)$$

From the definition K, by equation 81 of Part 10, it follows that

$$v_{i+1} = l_{i+1}\left(\frac{KV}{L}\right)_{i+1} \quad . \quad . \quad . \quad (81A)$$

Combining equations 103 and 81A and rearranging, gives the following equation for making the plate-to-plate calculations in the enriching section:

$$\frac{l_{i+1}}{d} = \frac{\frac{l_i}{d}+1}{\left(\frac{KV}{L}\right)_{i+1}} \quad . \quad . \quad . \quad . \quad . \quad (124)$$

Equation 124 combines the vapor-liquid equilibrium and component material balance steps for the plate-to-plate calculations to one relationship.

A component material balance around the lower part of the fractionator is written

$$l_{j+1} = v_j + b \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (106)$$

From the definition of K, it follows that

$$l_{i+1} = v_{j+1}\left(\frac{L}{KV}\right)_{j+1} \quad . \quad . \quad . \quad (81B)$$

Combining equations 106 and 81B and rearranging gives the following equation for making plate-to-plate calculations in the stripping section:

$$\frac{v_{j+1}}{b} = \frac{\frac{v_j}{b}+1}{\left(\frac{L}{KV}\right)_{j+1}} \quad . \quad . \quad . \quad . \quad . \quad (125)$$

This equation also combines the component material balance and phase equilibrium steps of the plate-to-plate calculations.

With temperature gradient established and expressed in terms of the equilibrium constant for the reference component, and with the L and V quantities fixed for each section (or each plate), plate-to-plate calculations may be made with equations 124 and 125, starting with $l_1/d$ and $v_1/b$, the ratios at the top and bottom plates as found from the preliminary calculations, such as those in Table 55.

*Feed plate mesh.* From the plate-to-plate calculations for the enriching and stripping sections, values of $l_n/d$ and $v_m/b$ are found for each component. These ratios are meshed at the feed plate for the distributed components to obtain the d/b ratios, from which the products may be computed. The feed condition must be taken into consideration in this operation. It is frequently necessary to obtain $v_{n+1}/d$ from $l_n/d$ by the relation

$$\frac{v_{n+1}}{d} = \frac{l_n}{d} + 1 \quad . \quad . \quad . \quad . \quad . \quad (103A)$$

Equation 103A is obtained by writing equation 103 for plate n and dividing by d. It is also frequently necessary to obtain $l_{m+1}/b$ from $v_m/b$ by the relation

$$\frac{l_{m+1}}{b} = \frac{v_m}{b} + 1 \quad . \quad . \quad . \quad . \quad . \quad (106A)$$

Equation 106A is obtained by writing equation 106 for plate m and dividing by b.

In addition to equations 103A and 106A there are two other relationships that are useful in making the feed plate mesh calculations. These equations are

$$\frac{v_m}{d} = \frac{v_{n+1}}{d} - \frac{v_f}{d} \quad . \quad . \quad . \quad . \quad . \quad (126)$$

and

$$\frac{l_n}{b} = \frac{l_{m+1}}{b} - \frac{l_f}{b} \quad . \quad . \quad . \quad . \quad . \quad (127)$$

Equations 126 and 127 are used where the feed is partially vaporized. Equation 126 must be applied with equation 103A and the results from the enriching section plate-to-plate calculations to get values of $v_m/d$. Likewise, equation 127

**TABLE 63. Enriching section plate-to-plate calculations for illustrating example by Thiele-Geddes method. (Example 28)**

Note: $\frac{L}{V}$=0.60 for each plate

| | Condenser; t=63 F | | | | Plate No. 1; t=105 F | | | |
|---|---|---|---|---|---|---|---|---|
| | $K_d$ | $K_d/y_d$ | $Dx_d$ | $y_1/y_d$ | $K_1$ | $K_1/y_d$ | $Dx_1$ | $y_2/y_d$ |
| Methane | 7.7 | 0.13 | 3.38 | 0.422 | 9.80 | 0.0431 | 1.12 | 0.426 |
| Ethane | 1.5 | 0.666 | 6.00 | 0.800 | 2.05 | 0.390 | 3.51 | 0.634 |
| Propane | 0.5 | 2.00 | 49.20 | 1.600 | 0.76 | 2.105 | 51.80 | 1.664 |
| Butane | 0.16 | 6.25 | 1.88 | 4.15 | 0.30 | 13.84 | 4.15 | 8.71 |
| Pentane | 0.054 | 18.50 | 0 | 11.50 | 0.105 | 109.50 | 0 | 66.0 |
| Hexane | 0.0144 | 69.50 | 0 | 42.10 | 0.04 | 1051.0 | 0 | 630.0 |
| Total | | | 60.46 | | | | 59.58 | |

| | Plate No. 3; t=119 F | | | | Plate No. 3; t=123 F | | | |
|---|---|---|---|---|---|---|---|---|
| | $K_2$ | $x_2/y_d$ | $Dx_2$ | $3y/y_d$ | $K_3$ | $X_3/y_d$ | $Dx_3$ | $y_4/y_d$ |
| Methane | 10.2 | 0.0418 | 1.09 | 0.425 | 10.5 | 0.0405 | 1.05 | 0.424 |
| Ethane | 2.24 | 0.2830 | 2.55 | 0.570 | 2.29 | 0.249 | 2.24 | 0.490 |
| Propane | 0.84 | 1.980 | 48.72 | 1.588 | 0.88 | 1.803 | 44.37 | 1.480 |
| Butane | 0.35 | 24.90 | 7.47 | 15.35 | 0.372 | 41.25 | 12.38 | 25.15 |
| Pentane | 0.141 | 468.0 | 0.02 | 281.0 | 0.1435 | 1958 | 0.09 | 1175.0 |
| Hexane | 0.052 | 12,100 | 0 | $7.25\times10^3$ | 0.0563 | $12.9\times10^4$ | 0 | $7.74\times10^4$ |
| Total | | | 59.85 | | | | 60.13 | |

| | Plate No. 4; t=132 F | | | | Plate No. 5; t=144 F | | | |
|---|---|---|---|---|---|---|---|---|
| | $K_4$ | $K_4/y_d$ | $Dx_4$ | $y_5/y_d$ | $K_5$ | $x_5/y_d$ | $Dx_5$ | $y_6/y_d$ |
| Methane | 10.93 | 0.0388 | 1.01 | 0.423 | 11.44 | 0.037 | 0.96 | 0.422 |
| Ethane | 2.45 | 0.200 | 1.80 | 0.520 | 2.63 | 0.198 | 1.78 | 0.519 |
| Propane | 0.95 | 1.558 | 38.35 | 1.335 | 1.040 | 1.283 | 31.58 | 1.17 |
| Butane | 0.417 | 60.25 | 18.07 | 36.6 | 0.473 | 77.50 | 23.26 | 46.9 |
| Pentane | 0.166 | $7.08\times10^3$ | 0.34 | $4.25\times10^3$ | 0.1955 | $2.17\times10^4$ | 1.04 | $1.3\times10^4$ |
| Hexane | 0.0665 | $11.63\times10^5$ | 0.03 | $7.0\times10^5$ | 0.0811 | $8.62\times10^6$ | 0.19 | $5.17\times10^6$ |
| Total | | | 59.60 | | | | 58.81 | |

| | Plate No. 6; t=160 F | | | |
|---|---|---|---|---|
| | $K_6$ | $K_6/y_d$ | $Dx_6$ | $y_{n+1}/y_d$ |
| Ethane | 12.3 | 0.0343 | 0.89 | 0.420 |
| Ethane | 2.94 | 0.1765 | 1.60 | 0.505 |
| Propane | 1.17 | 1.00 | 24.60 | 1.00 |
| Butane | 0.553 | 84.8 | 25.40 | 51.00 |
| Pentane | 0.24 | $5.41\times10^4$ | 2.60 | $3.24\times10^4$ |
| Hexane | 0.105 | $5.92\times10^7$ | 1.35 | $3.55\times10^7$ |
| Total | | | 56.44 | |

**TABLE 64. Feed plate mesh for Thiele-Geddes plate-to-plate calculations. (Example 28)**

| | $F_z$ | $V_{fyf}$ | $\frac{y_{n+1}}{y_d}$ | $\frac{y_m}{x_b}$ | $\frac{y_m/x_b}{y_{n+1}/y_d}$ | $\frac{V_{fyf}}{y_{n+1}/y_d}$ | $\frac{D}{B}\left(\frac{V_m}{V_{n+1}}\right)\left(\frac{y_m/x_b}{y_{n+1}/y_d}\right)$ |
|---|---|---|---|---|---|---|---|
| Methane | 26 | 25 | 0.420 | $12.0\times10^{10}$ | $28.6\times10^{10}$ | 59.50 | $23.95\times10^{10}$ |
| Ethane | 9 | 8 | 0.505 | $2.85\times10^5$ | $5.64\times10^5$ | 15.84 | $4.71\times10^5$ |
| Propane | 25 | 18 | 1.00 | 52.40 | 52.4 | 18.0 | 43.90 |
| Butane | 17 | 9 | 51.00 | 0.794 | 0.0156 | 0.1763 | 0.01306 |
| Pentane | 11 | 4 | $3.24\times10^6$ | 0.1874 | $0.578\times10^{-5}$ | $0.12\times10^{-5}$ | $0.488\times10^{-7}$ |
| Hexane | 12 | 2 | $3.55\times10^7$ | 0.0722 | $0.203\times10^{-8}$ | $0.56\times10^{-7}$ | $0.170\times10^{-8}$ |
| Total | 100 | 66 | | | | | |

| | $\frac{D}{V_{n+1}}\left(\frac{V_{fyf}}{y_{n+1}/y_d}\right)$ | $F_z-\left[\frac{D}{V_{n+1}}\left(\frac{V_{fyf}}{y_{n+1}/y_d}\right)\right]$ | $\left[\frac{D}{B}\left(\frac{V_m}{V_{n+1}}\right)\left(\frac{y_m/x_b}{y_{n+1}/y_d}\right)\right]+1$ | $Bx_b$ | $Dy_d$ |
|---|---|---|---|---|---|
| Methane | 23.80 | 2.20 | $23.95\times10^{10}$ | $0.92\times10^{-11}$ | 26— |
| Ethane | 6.34 | 2.66 | $4.71\times10^5$ | $0.57\times10^{-5}$ | 9— |
| Propane | 7.20 | 17.80 | 44.9 | 0.4 | 24.6 |
| Butane | 0.0705 | 16.93 | 1.01306 | 16.7 | 0.3 |
| Pentane | $0.048\times10^{-3}$ | 11— | 1+ | 11— | $0.48\times10^{-4}$ |
| Hexane | $0.224\times10^{-7}$ | 12— | 1+ | 12— | $0.224\times10^{-7}$ |
| Total | | | | 40.10 | 59.90 |

must be applied with equation 106A and the results of the stripping section plate-to-plate calculations to get values of $l_n/b$.

These results give two ways of meshing for partially vaporized feed. One relationship is

$$\frac{d}{b} = \frac{l_n/b}{l_n/d} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (128)$$

The ratio $l_n/d$ for equation 128 is found directly from the enriching section plate-to-plate calculations while the ratio $l_n/b$ is found by applying equations 106A and 127 to the stripping section plate-to-plate calculations.

The other ratio relationship is

$$\frac{d}{b} = \frac{v_m/b}{v_m/d} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (129)$$

The ratio $v_m/b$ for equation 129 is found directly from the stripping calculations while the ratio $v_m/d$ is found by applying equations 103A and 126 to the enriching section plate-to-plate calculations.

When the feed is all liquid, the feed plate mesh is simple. The relationship for this condition is a simple case of equation 129. When the feed is liquid at the boiling point $v_m/d = v_{n+1}/d$, which is given by equation 103A, making

$$\frac{d}{b} = \frac{v_m/b}{l_n/d + 1} \quad . \quad . \quad . \quad . \quad . \quad . \quad (130)$$

When the feed is all vapor the feed plate mesh is a simple case of equation 128. For vapor feed at the dew point $l_n/b = l_{m+1}/b$, which is given by equation 106A, making

$$\frac{d}{b} = \frac{v_n/b + 1}{\frac{l_n}{d}} \quad . \quad . \quad . \quad . \quad . \quad (131)$$

These feed plate mesh equations are in different form than those in Hummel's article. The feed plate mesh operation will be illustrated in an example.

## ILLUSTRATIONS

These three multicomponent plate-to-plate calculation methods are illustrated by detailed solutions of the same example. The example is the one used to illustrate the preliminary steps for multicomponent fractionation calculations given in Tables 55 and 57 of Part 12.

The vapor-liquid equilibrium ratio values used in these calculations are given in Fig. 52, where K = y/x values are plotted against temperature for propane and butane, the key components. Also, the relative volatilities for the six components (referred to propane) are also plotted against temperature in Fig. 52. These vapor-liquid equilibrium data are all at 300 p.s.i.a. It will be assumed that the entire system is at this pressure. The example is stated as follows:

Find the number of theoretical plates required for the separation shown in Table 55 of Part 12 when returning 90 mols of reflux per 100 mols of feed. In this solution it will be assumed that the molal overflow and vapor boilup are constant in each section, making heat balances unnecessary. The vapor and liquid quantities and L/V and V/L ratios are:

| *Section* | L | V | L/V | V/L |
|---|---|---|---|---|
| Enriching | 90 | 149.9 | 0.60 | 1.667 |
| Stripping | 124 | 83.9 | 1.48 | 0.677 |

$L_f = 124 - 90 = 34$

$V_f = 149.9 - 83.9 = 66$

These quantities will be used in the solution of the example by each of the three methods.

*Example 27:* Solve the above problem by the Lewis-Matheson method.

This solution is presented in Tables 58, 59, and 60, which, along with Tables 55 and 57, present complete and detailed calculations for this multicomponent separation. In Tables 60, the enriching and stripping calculations are meshed by comparing the liquid and vapor fractions of the feed computed two ways.

*Example 28:* Solve the above problem by the Thiele-Geddes method, which is summarized in Table 61, for convenience.

This solution is presented in Tables 62, 63 and 64. In applying the material balance equations 109 and 112, constant values of V/L and L/V were used. This simplification is not necessary as can be seen by the equations.

**TABLE 65**

## SUMMARY OF HUMMEL METHOD

**Plate-to-plate calculations using component ratios, KV/L ratios, and equilibrium gradient to determine products for given reflux ratio and number of plates.**

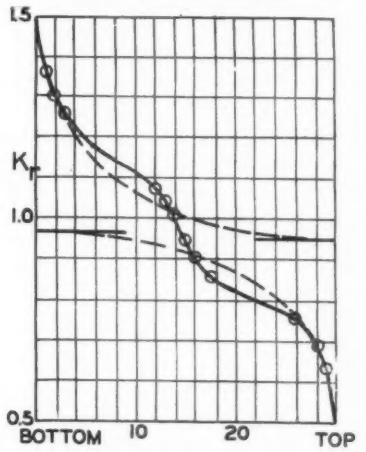
*Preliminaries:*

1. Make component material balance for desired separation.
2. Assume number of theoretical plates.
3. Assume reflux pumpback and compute L/V ratios.
4. Prepare graph of equilibrium constant for one key component and relative volatilities for other components vs temperature.

*Temperature and Equilibrium Constant Gradient:*

1. Starting with desired products, make plate-to-plate calculations from both ends of tower to define these portions of the temperature gradient.
2. Estimate temperatures and compositions at feed plate.
3. Starting with feed plate conditions, make plate-to-plate calculations both ways from feed plate to define these portions of the temperature gradient.
4. Construct plot of K for reference key ($K_r$) vs plate number.

**Asymptotic curves neglect build up of nondistributed components.**




**THEORETICAL PLATES**

*Series plate-to-plate calculations:*

Using estimated $K_r$ gradient and values of L and V at various points, make series plate-to-plate calculations for each distributed component in both sections. Following equations and forms are used:

Enriching section

$$l_1/d = \left(\frac{l_{1-1}}{d} + 1\right) \Big/ \left(\frac{KV}{L}\right)_1$$

| Form | | | |
|---|---|---|---|
| Plate | K | KV/L | $l/d$ |

Stripping section

$$v_j/b = \left(\frac{v_{j-1}}{b} + 1\right) \Big/ \left(\frac{L}{KV}\right)_j$$

| Form | | | |
|---|---|---|---|
| Plate | K | L/KV | v/b |

Carry out these calculations from each end of tower, obtaining $l_n/d$ and $v_m/b$ at feed plate for each distributed components.

*Feed plate mesh:*

Ratio d/b is found from above results and following equations:

Feed at boiling point: $d/b = \dfrac{(v_m/b)}{(l_n/d) + 1}$

Feed at dew point $d/b = \dfrac{(v_n/b) + 1}{l_n/d}$

By component material balance: $b = \dfrac{f}{(d/b) + 1}$, $d = f - b$.

With d and b, find $l_n$ and $v_m$ and then check temperature and $K_r$.

In making the feed plate mesh calculations by this method, the amounts of methane and ethane in the bottoms product and the amounts of pentane and hexane in the distillate must be found in order to permit checking the assumed plate temperatures. The methane and ethane in the bottoms are found directly from equation 119 in the same manner the propane and butane are calculated, as shown in Table 64. The quantities of all components in the distillate except pentane and hexane, are found by

$$Dy_d = Fz - Bx_b$$

Pentane and hexane in the distillate must be found directly from equation 119 by noting that the term

$$\left[\frac{D}{B}\left(\frac{V_m}{V_m + V_f}\right)\left(\frac{y_m/x_b}{y_{n+1}/y_d}\right)\right]$$

is close to zero so that equation 119 becomes

$$Bx_b = Fz - \left[\left(\frac{D}{V_m + V_f}\right)\left(\frac{V_f y_f}{y_{n+1}/y_d}\right)\right]$$

from which

$$Dy_d = \left[\left(\frac{D}{V_m + V_f}\right)\left(\frac{V_f y_f}{y_{n+1}/y_d}\right)\right] \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (132)$$

Equation 132 applies only to the higher boiling non-distributed component.

From the tabulated calculations and results it can be seen that both the Thiele-Geddes and the Lewis-Matheson

**TABLE 66. Stripping section plate-to-plate calculations by Hummel method, L/V = 1.48. (Example 29)**

| Plate No. | Temp., F | Propane | | | Butane | | | Pentane | | | Hexane | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | K | L/KV | v/b | α | L/KV | v/b | α | L/KV | v/b | α | L/KV | v/b |
| 1′ | 280 | | | 10.70 | | | 3.52 | | | 1.313 | | | 0.544 |
| 2′ | 266 | 2.24 | 0.660 | 17.70 | 0.540 | 1.220 | 3.70 | 0.290 | 2.27 | 1.018 | 0.162 | 4.06 | 0.380 |
| 3′ | 257 | 2.14 | 0.690 | 27.10 | 0.536 | 1.288 | 3.66 | 0.280 | 2.46 | 0.818 | 0.154 | 4.48 | 0.308 |
| 4′ | 249 | 2.06 | 0.718 | 39.10 | 0.533 | 1.346 | 3.46 | 0.273 | 2.62 | 0.693 | 0.148 | 4.85 | 0.270 |
| 5′ | 243 | 2.00 | 0.740 | 54.20 | 0.531 | 1.393 | 3.20 | 0.270 | 2.74 | 0.618 | 0.144 | 5.14 | 0.247 |
| 6′ | 233 | 1.88 | 0.786 | 70.10 | 0.529 | 1.485 | 2.83 | 0.261 | 3.01 | 0.537 | 0.138 | 5.69 | 0.219 |
| 7′ | 225 | 1.80 | 0.821 | 86.60 | 0.527 | 1.560 | 2.46 | 0.257 | 3.20 | 0.480 | 0.135 | 6.09 | 0.200 |
| 8′ | 215 | 1.69 | 0.875 | 100.00 | 0.523 | 1.670 | 2.07 | 0.250 | 3.49 | 0.424 | 0.128 | 6.84 | 0.175 |
| 9′ | 205 | 1.58 | 0.935 | 108.00 | 0.520 | 1.800 | 1.92 | 0.244 | 3.83 | 0.372 | 0.122 | 7.68 | 0.153 |

**TABLE 67. Enriching section plate-to-plate calculations by Hummel method, V/L = 1.667 for each plate. (Example 29)**

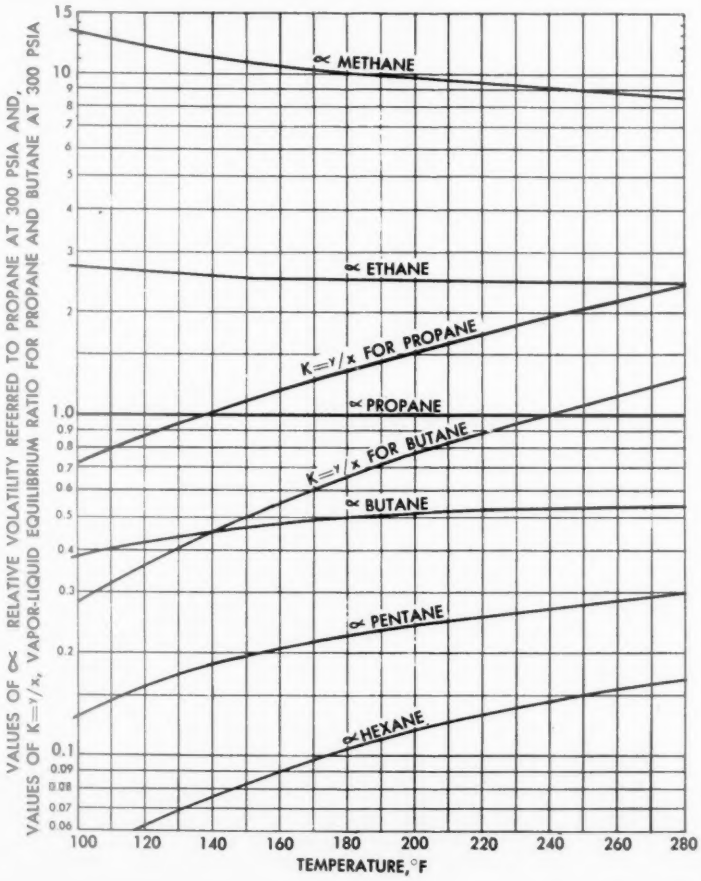
| Plate No. | Temp., F | Propane | | | Butane | | | Ethane | | | Methane | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | K | KV/L | l/d | α | KV/L | l/d | α | KV/L | l/d | α | KV/L | l/d |
| 1 | 105 | | | 3.00 | | | 37.20 | | | 0.434 | | | 0.064 |
| 2 | 119 | 0.84 | 1.400 | 2.86 | 0.42 | 0.588 | 65.00 | 2.62 | 3.67 | 0.391 | 12.00 | 16.80 | 0.063 |
| 3 | 123 | 0.88 | 1.465 | 2.64 | 0.43 | 0.630 | 105.00 | 2.60 | 3.81 | 0.365 | 11.80 | 17.30 | 0.061 |
| 4 | 132 | 0.95 | 1.580 | 2.30 | 0.44 | 0.695 | 152.00 | 2.58 | 4.08 | 0.334 | 11.50 | 18.20 | 0.058 |
| 5 | 144 | 1.04 | 1.730 | 1.91 | 0.45 | 0.779 | 196.00 | 2.53 | 4.38 | 0.305 | 11.10 | 19.20 | 0.055 |
| 6 | 160 | 1.17 | 1.95 | 1.49 | 0.475 | 0.927 | 212.00 | 2.50 | 4.88 | 0.267 | 10.50 | 20.50 | 0.051 |

**TABLE 68. Feed plate mesh for Hummel plate-to-plate calculations. (Example 29)**

| | From stripping calculations | | | | From enriching calculations | | | | Products and temp. check | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $v_{m/b}$ | $l_{m+1/b}$ | $l_{f/b}$ | $l_{n/b}$ | $l_{n/d}$ | $v_{n+1/d}$ | $v_{f/d}$ | $v_{n/d}$ | d/b | b | d | $l_n$ |
| Methane | | | | | 0.051 | 1.051 | 0.962 | 0.089 | | | 26.00 | 1.28 |
| Ethane | | | | | 0.267 | 1.267 | 0.889 | 0.378 | | | 9.00 | 2.40 |
| Propane | 108.00 | 109.00 | 17.50 | 91.5 | 1.490 | 2.490 | 0.731 | 1.759 | 61.5 | 0.40 | 24.60 | 36.60 |
| Butane | 1.92 | 2.92 | 0.479 | 2.441 | 212.00 | 213.0 | 30.00 | 183.00 | 0.012 | 16.80 | 0.20 | 41.00 |
| Pentane | 0.372 | 1.372 | 0.636 | 0.736 | | | | | | 11.00 | | 8.10 |
| Hexane | 0.153 | 1.153 | 0.833 | 0.320 | | | | | | 12.00 | | 3.80 |
| Total | | | | | | | | | | 40.20 | 59.80 | 93.18* |

*This total $\Sigma l_n$ should equal 90.0 to prove temperature gradient used. However, it is very sensitive to the results for propane and butane and might easily come out below 90 as above. Note that all ln values except 41.0 for butane are in good agreement with $l_n$ values in Table 57.

**FIG. 52. Vapor-liquid equilibrium and relative volatility ratios for 6 hydrocarbons, 300 psia for illustrating example.**


VALUES OF ∝ RELATIVE VOLATILITY REFERRED TO PROPANE AT 300 PSIA AND,
VALUES OF K=y/x, VAPOR-LIQUID EQUILIBRIUM RATIO FOR PROPANE AND BUTANE AT 300 PSIA
∝ METHANE
∝ ETHANE
K=y/x FOR PROPANE
∝ PROPANE
K=y/x FOR BUTANE
∝ BUTANE
∝ PENTANE
∝ HEXANE
TEMPERATURE, °F

method are in good agreement, as would be expected since they are both rigorous. For this type of problem the Lewis-Matheson method is more rapid.

*Example 29:* Solve the above problem by the Hummel method. Table 65 gives a summary of the Hummel method and includes a plot illustrating the method of establishing $K_r$ gradient. Only one gradient is shown on this plot but it might be necessary to construct more than one gradient before a satisfactory solution is obtained.

The calculations either way from the feed plate would be started from the results of the feed plate temperature calculations in Table 57. These preliminary plate-to-plate calculations from the feed plate are sensitive to the starting compositions, which are onyl approximated in Table 57.

In trying out the proposed method of finding the $K_r$ gradient the author tried starting with $v_m$ and $l_m$ from Table 57 and could not check the plate temperatures obtained in the Lewis-Matheson calculations in Tables 58 and 59. The latter are correct. It might be concluded that the proposed method of establishing the $K_r$ gradient is a good first approximation.

The calculations by the Hummel method are given in Tables 66, 67 and 68. This application was not strictly in accordance with the author's procedure because temperatures on all plates were already known from the Lewis-Matheson and Thiele-Geddes solutions.

This method is much more rapid than the Thiele-Geddes method. It is faster than the Lewis-Matheson method also. The objection is that individual plate temperatures cannot be checked.

In Table 68 the feed plate mesh calculations give the products and prove the correctness of the assumed temperature gradient. The latter is tested by $\Sigma l_n$ being equal to 90, which is $L_n$.

In the next installment short-cut multicomponent fractionation methods will be presented.

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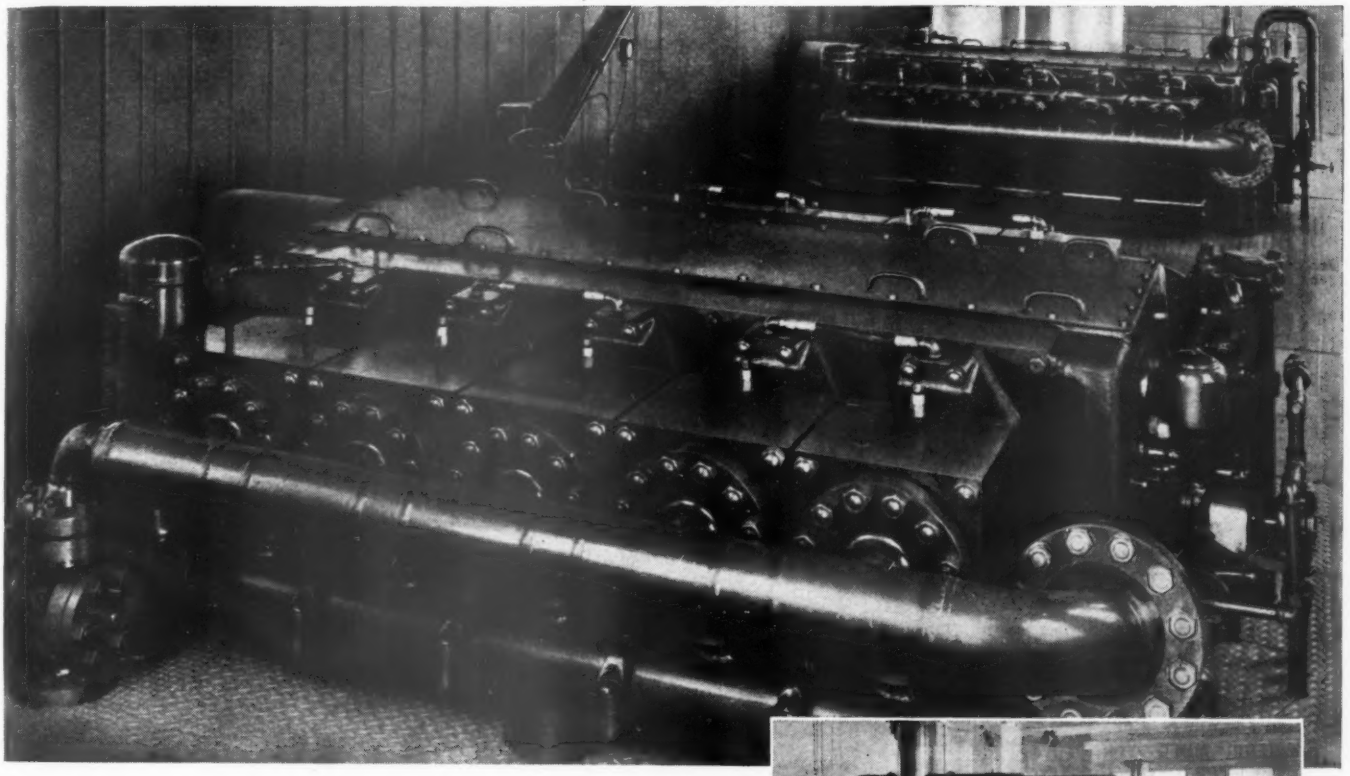

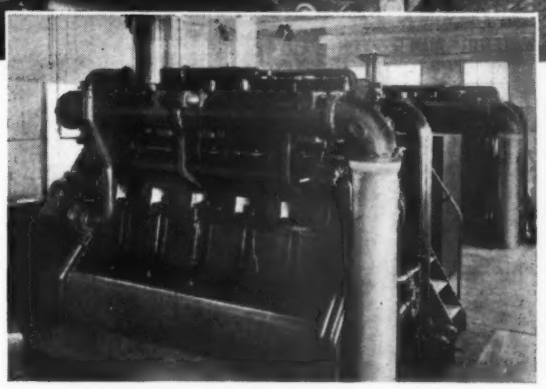

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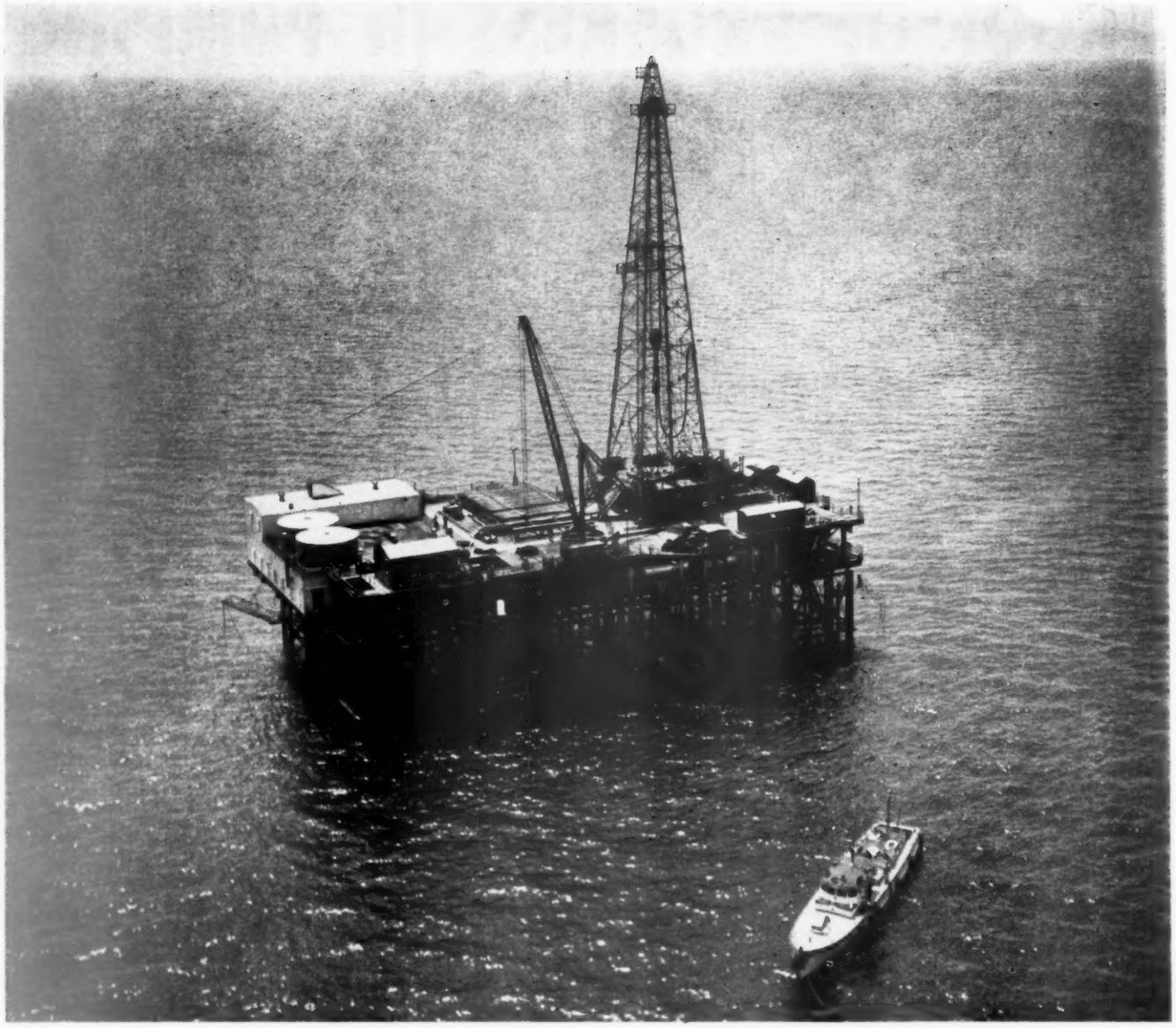


**Humble's $1,200,000 drilling platform at Grand Isle No. 1 was built on 100 H-beam piles driven from 147 to 197 ft into the soft ocean bed, which is 50 ft below the surface of the Gulf. The first deck is 32 ft above the mean water level, the second deck is 14 ft higher, and the derrick floor is 60 ft above the mean water level. The platform and unguyed derrick are designed to weather 120 mph gales and 35 ft waves.**

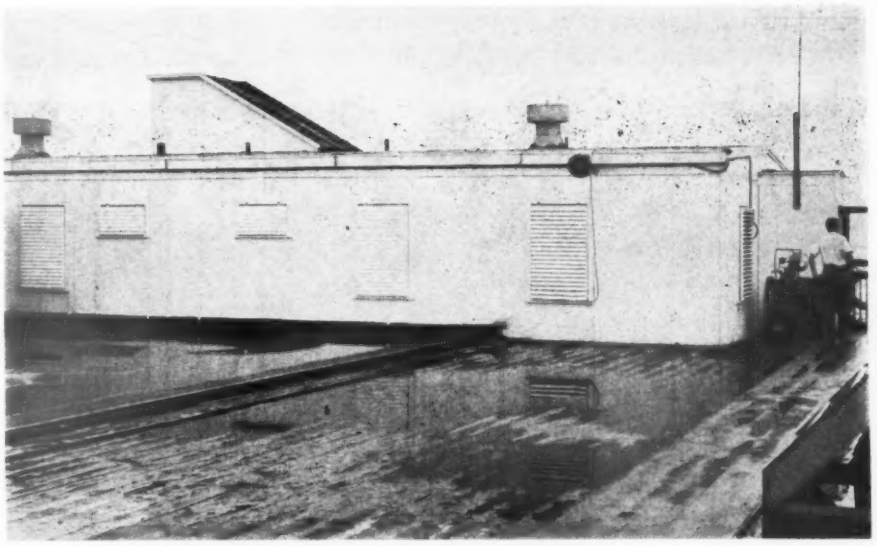
# Humble's offshore drilling program

By K. MARSHALL FAGIN, *Field Editor*

EXCLUSIVE

WITH its first well drilling in salt below 8000 ft from the largest drilling platform ever built in open sea water, the Humble Oil and Refining Company of Houston, Texas, is launching a multi-million dollar drilling program to explore and develop the potential petroleum reservoirs it has leased from the State of Louisiana in the Gulf of Mexico tidelands. About 10 ft of oil sand was discovered at 7100 ft in this first well, Grand Isle No. 1, State lease 801, which is located about 7.5 miles south of Grand Isle and 53 miles south of New Orleans. Although this sand may not make a commercial well, it is a good indication that commercial quantities of oil will be found somewhere around the flank of the salt dome prospect, which is about three miles in diameter. The salt dome was topped at about 7600 ft in this first well and the well will probably be drilled to about 8600 ft in search of flank sands that might be found beneath the salt, if it should be an overhang.

A corner of the top deck of Humble's platform is occupied by the top floor of the living and office quarters, which can accommodate as many as 54 men. Steel window blinds and other construction features are designed to protect personnel and property during storms and hurricanes that occur frequently in the Gulf area. Inside stairways connect the floors of the living quarters.



Smaller drilling platforms have been constructed for testing three other offshore prospects leased by Humble, and two more are being built. By September 1, 1948, Humble expects to have a total of five or six wells drilling on its offshore prospects. Other companies are expected to have about nine or ten drilling operations underway at that time, making a total of about 15 active rigs. There are several factors that encourage the oil companies to begin drilling these offshore leases as soon as possible:

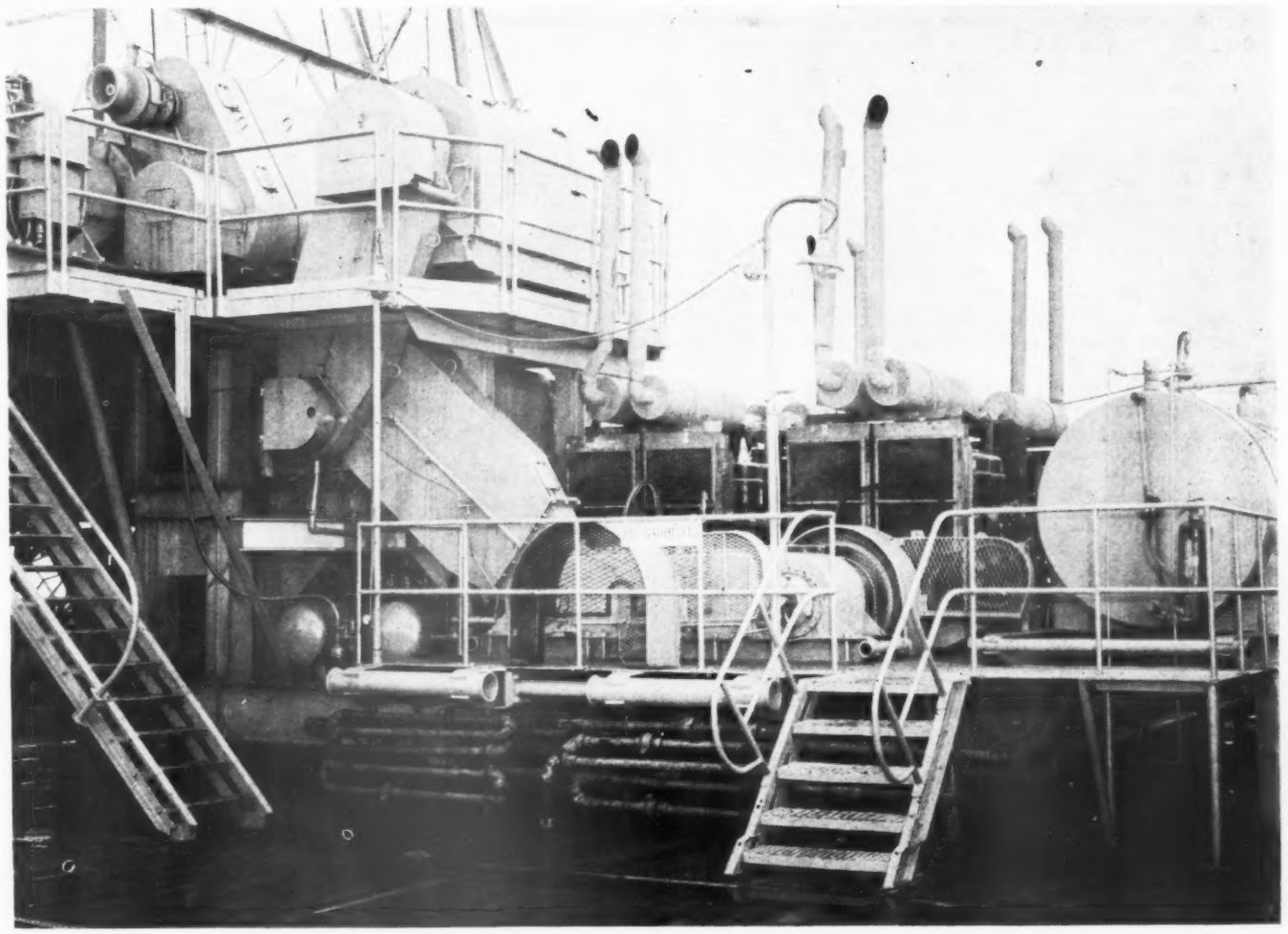
1. Oil producing reservoirs have been discovered on two of the eight exploratory wells that have been completed or are in the testing and completion stage: Superior Oil Company's State No. 1 (Creole field discovery), March, 1938, and Kerr-McGee's Block 32 No. 1, November, 1947.

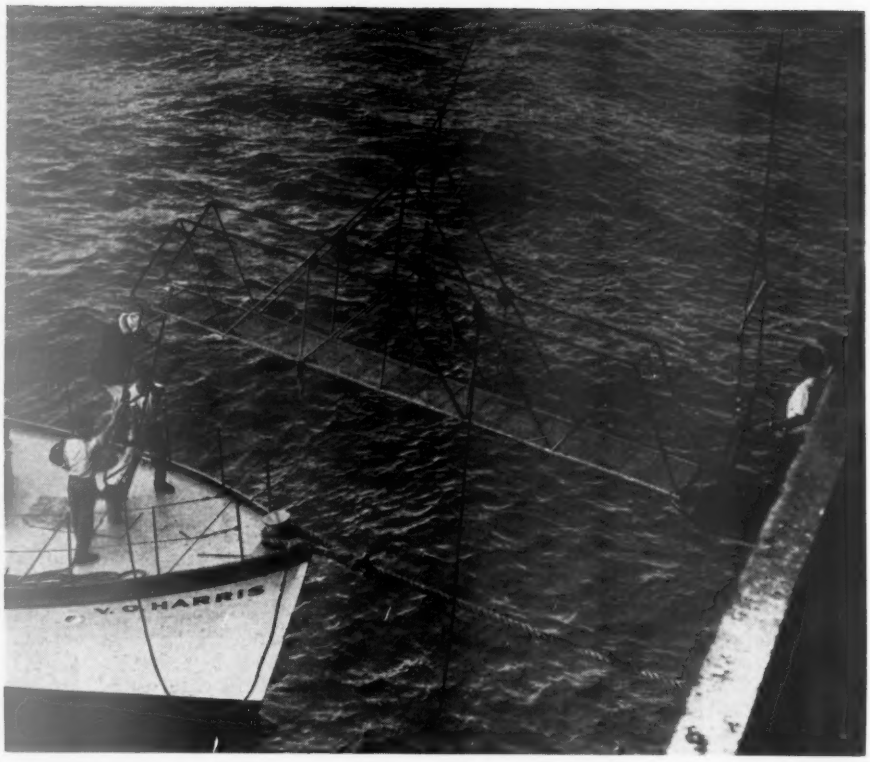
A gas producing reservoir has been discovered by another one of the eight wells: Barnsdall's Breton Sound No. 1, 1948.

Oil and gas shows have been found and are being tested in three of the eight wells: Magnolia's Block 72 No. 1 (Ship Shoal area); Magnolia's Block 45 No. 1 (Eugene Island area), and Humble's Grand Isle No. 1.

Only two of the eight wells have been abandoned: Magnolia's Block 58 No. 1 (Eugene Island area), which had some oil and gas shows, and Magnolia's Block

Eight diesel engines mounted on a 3-ft substructure on the top deck of the drilling platform are used to supply as much as 1200 hp to the extra-heavy drawworks (upper left) mounted on the 14-ft substructure at the derrick floor level. Chains used in the compound transmission and drawworks drive are protected by oil-tight guard cases.






**A hinged-type landing device has been constructed by Humble for easier and safer transfer of personnel from the platform to boats. It has proved much more satisfactory in high seas than the fixed-type escape catwalks and rope ladders used heretofore.**

94 No. 1 (Eugene Island area), which found the top of a salt dome at a shallow depth. Commercial quantities of petroleum may be discovered at some future time in the vicinity of these two dry holes, especially around the flanks of the salt dome discovered in Block 94, which is about 25 miles offshore.

The petroleum discovery record thus far is therefore very good when one considers that as many as 12 deep wells have been drilled around some of the prolific salt dome fields on shore before the fields were discovered. It is too early to predict the reserves of any of these discoveries. Even the Creole field may be extended, or deeper production discovered, so that it may produce more than the present estimate of 5,000,000 bbl. Almost 3,000,000 bbl has already been produced.

2. Some of the leases were taken in 1945. All leases are for a 5-year period, so drilling must be started and continued until production is established, or the lease will revert to the State of Louisiana and may be bid in by other companies when sales are held. One drilling operation usually can hold a block of 5000 acres.

3. The annual rentals for holding a lease that is not being drilled are one-half of the original bonus. Some of the lease blocks brought a bonus of about $200,000. The companies that paid that much initially must therefore pay $100,000 rental each year to hold the block, or begin drilling. This high rental requirement is probably the principal reason why offshore drilling activity will continue to increase during the next three years.

The preliminary geophysical reconnaissance of the tideland area of South Louisiana is about over, and the detailed surveys and drilling are increasing, so that the least attractive prospects can be dropped to avoid rental payments.

4. More than 50 structures have been found so far in the Louisiana tidelands area, and perhaps 50 additional prospects will be discovered. All in all, the offshore oil prospects in this area present a very attractive gamble for those companies that are able to spend the millions of dollars that are necessary now to find, develop, and produce the hundreds of millions of barrels of crude oil that are bound to be found and produced from these prospects.

The giant double-deck size and cost ($1,200,000) of Humble's first offshore drilling platform at Grand Isle No. 1 is almost enough in itself to discourage small and medium-sized oil operators from attempting to drill exploratory wells in offshore waters. Humble Oil officials, themselves, are planning to avoid expenditures of this magnitude in future offshore operations by designing smaller platforms to be used in conjunction with a floating drilling barge. Nevertheless, the tremendous steel structure at Grand Isle No. 1 may prove to be a valuable base for offshore operations in the area as well as the surface location for as many as seven directionally drilled wells.

The two decks of the platform are 100 ft wide by 206 ft long. They are supported by twenty-five 10 by 10 by 80-ft long pipe templets through which one hundred 10¾-in. by 270-ft steel H-pilings were driven to an average penetration depth of 197 ft. The first deck is 32 ft above sea level, and the top deck is 46 ft above sea level. The soft muck of the ocean bed is about 50 ft below sea level.

The derrick floor is supported by a 14-ft substructure that is built on the top deck. The gin pole on the heavy 136-ft drilling derrick is about 205 ft above sea level and 255 ft above the ocean floor, which is the height of the flag pole on the Humble building at Houston.

More than 2500 tons of steel was used in the construction of this mammoth platform, which weighs about 5000 tons when loaded with all of the drilling machinery, pipe, mud, and other supplies necessary for a 15,000-ft well. Skin friction between the H-beam piling and the soft silty clays in the ocean bed is all that supports this tremendous weight. Many of the piles must support loads of as much as 250,000 lb each.

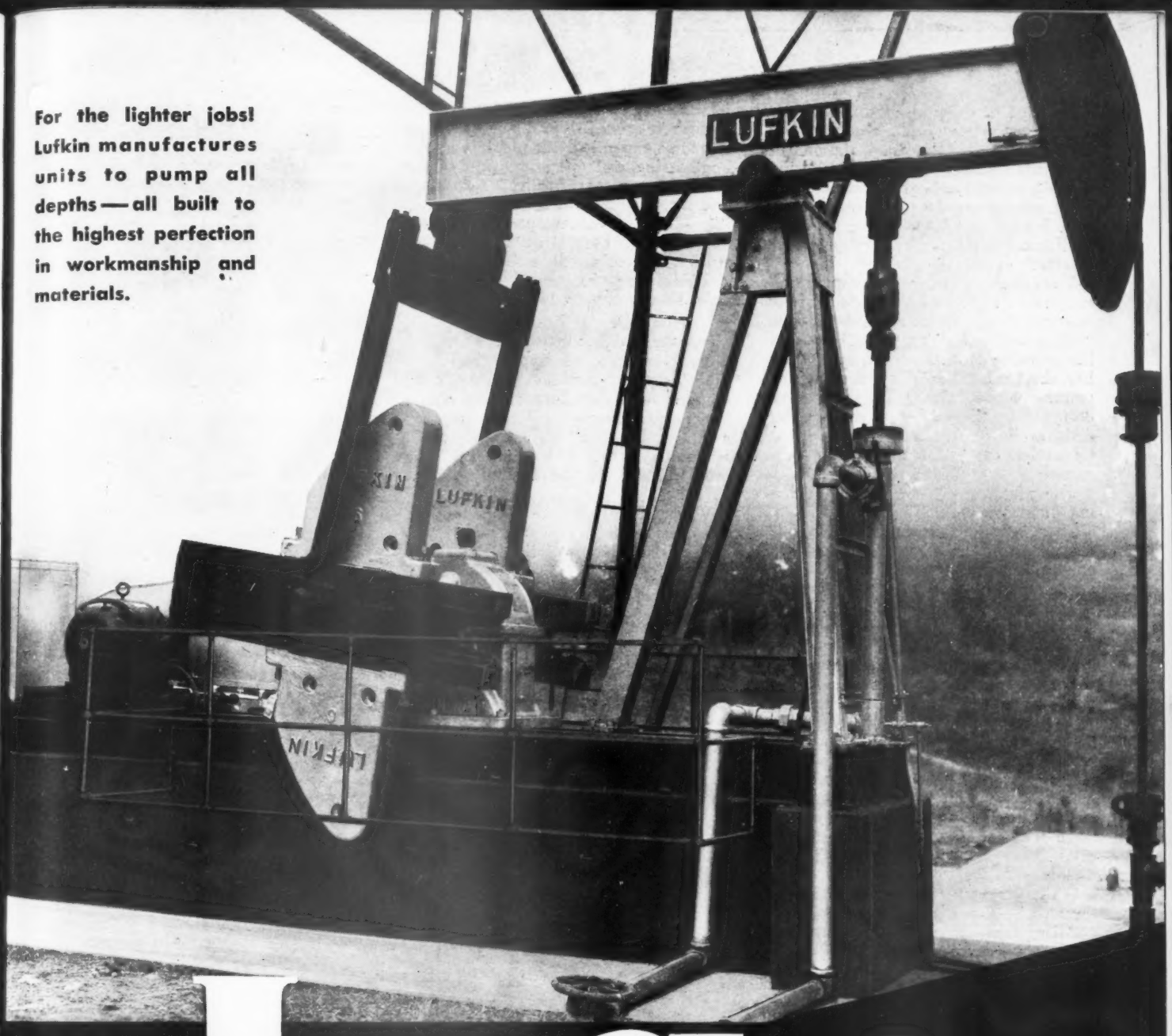
Humble's engineers gathered all the data they could find on wave forces, wave heights, and wave frequencies for use in calculating the forces that might assault the structure during Gulf storms of hurricane velocity. From these data, a study of U. S. Weather Bureau records, and tests made on test piles driven into the ocean bed, the depth of piling penetration required was calculated to be 147 to 197 ft.

The 18-ton templets were prefabricated at New Orleans with 8-in. pipe spacers and braces welded between the four 20-in. pipe legs through which the H-beam pilings were driven. These templets were transported to the well location on two LSM barges and set up in place by huge cranes. The templets sank about 15 ft into the soft ocean floor before the H-beams were driven through them.

The first 120-ft lead section of H-beam piling was driven on November 30, 1947. Three 53-ft sections were added to each lead section, making the total length of each piling 279 ft; 32 ft of the piling remained in the templet above sea level, 50 ft of the piling remained in the submerged portion of the templet above the ocean floor, and 197 ft was driven into the ocean bed. The upper half of each templet was sheathed with layers of spun glass and tar coating material as protection against corrosion and wave action.

The treated timber decks of the structure are supported by 24-in. and 30-in. I-beams that rest on the H-beam piles. No guy wires or external braces of any kind are used to help the structure or derrick resist the pounding of the Gulf or the force of hurricane winds. The platform and derrick are designed to withstand 120 mph gales and waves 35 ft high.

Boats can approach the platform from any direction, and personnel can be transferred with comparative safety in high seas by means of unique landing ramps constructed on each of the four

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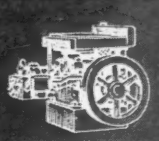
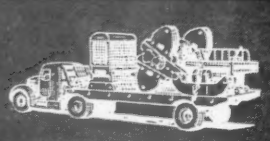

LUFKIN-COOPER-BESSEMER ENGINES


LUFKIN OIL FIELD AND INDUSTRIAL TRUCK TRAILERS

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sides. One of these is shown in an accompanying photograph. The boats are brought in under the ramp, the end of the ramp ladder is pulled down to the deck by ropes, the boat is tied up about 15 ft away from the platform, and the rope is kept taut between the boat and platform by putting the propeller in reverse.

The ladder end of the personnel ramp moves up and down with the deck of the boat and the platform end swivels freely on a ball and socket joint. The ramp has guard rails on the sides, and a rubber shock absorber is attached to the bottom of the ladder. The ramp was designed by the petroleum engineering division of Humble and has made it a lot easier and safer to transfer personnel.

The platform contains complete living quarters, including a dining room, kitchen, recreation room, and bedrooms for 54 men. Most of these quarters are on the first deck. Seven bedrooms and an office with radio equipment are on the top deck and connected by an inside staircase. The quarters are steam heated for winter, ventilated by fans in summer, and are complete with water and sewer systems for the comfort of the three drilling crews and other personnel.

Thousands of sacks of drilling mud materials and cement are stored on the first deck between the living quarters and the well. These materials weigh more than 1,600,000 lb and serve to cushion the living quarters from the noise of the pumps and drilling machinery. These materials also are immediately available to combat any blowouts that might threaten the drilling of the well or the safety of the structure.

All of Humble's marine drilling operations are powered by diesel oil engines as a safety precaution. Skid-mounted diesels are used to drive the three large mud pumps, which are enclosed together with three 200-bbl mud tanks on the first deck between the dry mud storage and the well. Horizontal fuel and water tanks are mounted around the well on the other side of the first deck.

The top deck of the platform contains the pipe and casing racks, fresh water storage tanks, a diesel-electric generating house, a well-logging house, a large crane, the drilling crew doghouse and office, and the drilling rig and engines. Fresh water has to be barged to the platform from New Orleans along with the food and other supplies.

The usual land-type of casing suspension could not be used on the well drilled from this platform, due to the 80-ft unsupported section between the ocean floor and the wellhead. Casing of 24-in. diam was set about 200 ft in the ocean bed and cemented back to the surface as a conductor pipe; 20-in. casing was set inside this to about 500 ft and cemented back to the wellhead. This helped to stiffen the unsupported section. The mid-string of casing was cemented back to the surface of the ocean floor, so that only the top 80-ft section would be in suspension from the wellhead.

There are many other unusual problems connected with the drilling of wells in offshore areas. All problems are being solved as expediently as possible by the engineering and operating skill of the men and companies involved. New ideas and methods evolved from the pioneering efforts of the companies now engaged in offshore drilling operations will undoubtedly reduce the cost of developing the great offshore oil and gas fields that are bound to be discovered.

Grande Isle, a 7-mile long island along the North shore of the Gulf of Mexico, has been selected as the site of the land base that is being built by Humble for its offshore drilling operations. It is connected to New Orleans by a shell and concrete highway about 110 miles long. Only a few miles at the southern end of the highway is not paved.

Warehouses, an office building, a "quarter boat" (built on a sandy part of the island that will be the site of a camp for the married employees), and more than 400 ft of docking facilities and boat pens have already been constructed. The quarter boat at Grand Isle provides eating and sleeping quarters for the employees of the land base.

A radar triangulation station has been built at the Grand Isle base. The screen-type radar aerial is erected on the top of a 136-ft derrick. Radar has been used in over-water surveying and is an aid in navigation. Almost all of the vessels being used in offshore exploration and drilling activities are equipped with very-high-frequency radio and radar sets.

An oceanographer is employed by Humble at Grand Isle to provide the fleet of crew boats, tugs, and barges with continuous wave and weather information. Using data from the U. S. weather bureau, it is possible to make fairly accurate forecasts of wave height and weather conditions. The immediate

**Guide plates are being welded to the top of one of the tubular steel templets before the 10¾-in. H-beam is lowered and driven into the ocean bed as a piling. The tubular steel templets are 72 ft long and weigh about 18 tons. They were put into position and sunk about 15 ft into the ocean bed. The upper half of the templets are covered with a special glass fiber anti-corrosion wrapping.**

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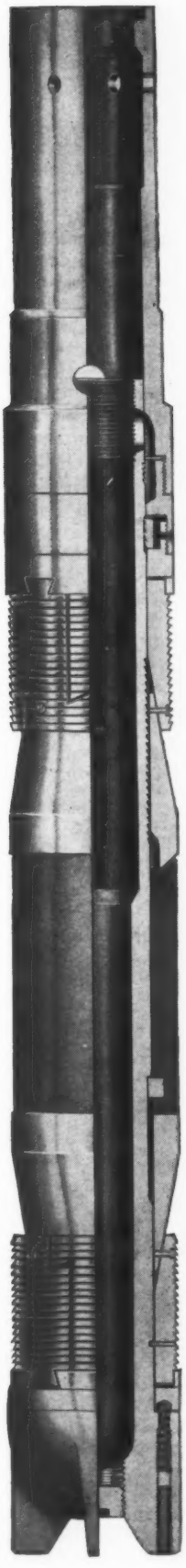

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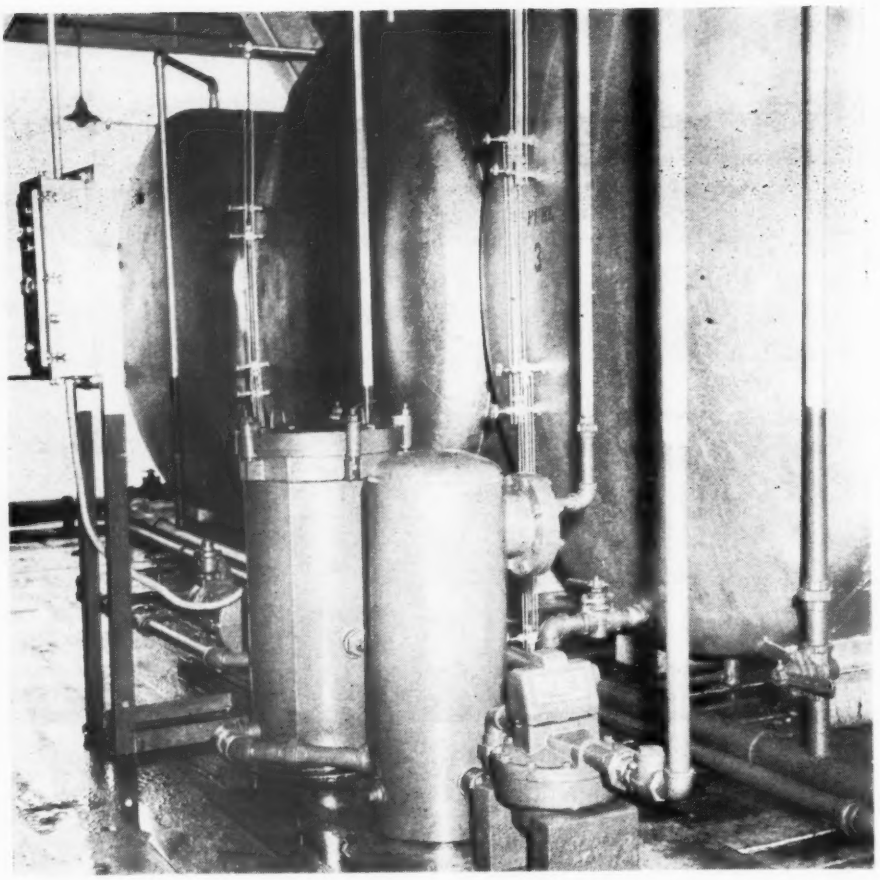


**Fuel oil is pumped through filters and a meter (foreground) from the storage tanks on the first deck to the diesel engines that drive the rig and auxiliary equipment. Electricity from the generator house on the top deck is used to drive fuel oil pump.**

availability of this service adds a great deal to the safety and efficiency of offshore operations.

It was necessary for Humble to spend a large amount of money on dredging operations in the harbor area of Bayou Rigard on the north side of Grand Isle, and more than a mile of channel had to be dredged seaward from Barataria Pass, so that deep-draft seagoing tugs and barges could enter the harbor. The seaward channel across submerged sand bars provides a minimum draft of 12 ft and cost about $125,000.

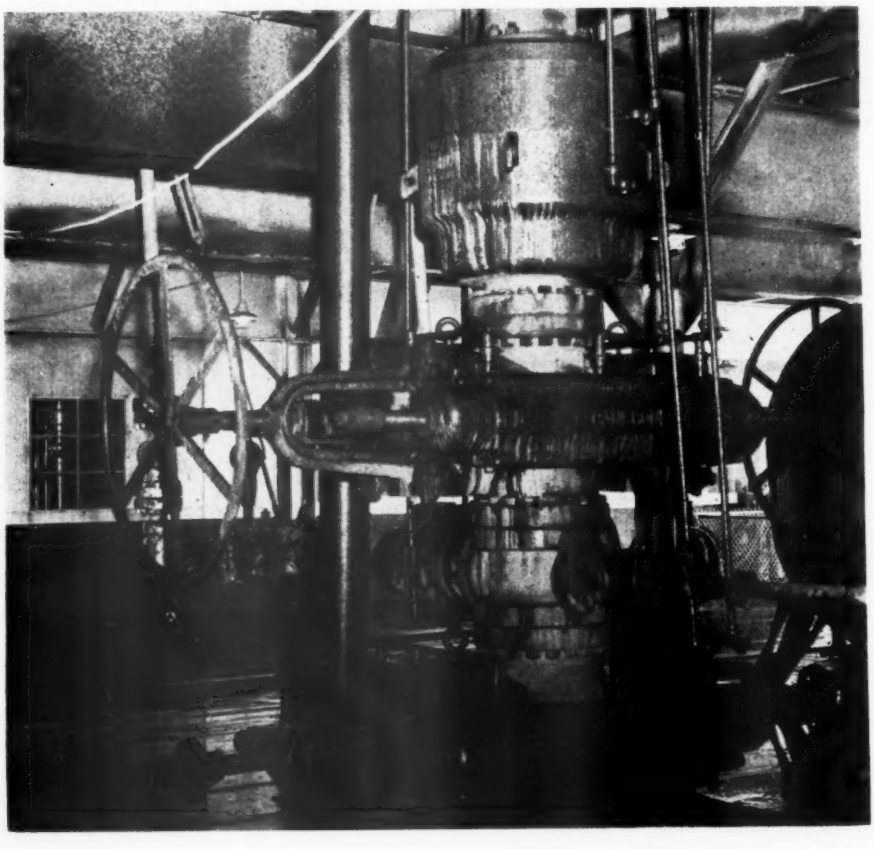
The Humble operations terminal occupies a 9-acre tract of filled area along Bayou Rigard and is adjacent to a 50-acre tract that will be used for a campsite. About $500,000 has already been spent on this development. The problems that arise and the investments that are required to solve these problems are tremendous compared to land-based operations. It is estimated that Humble has spent about $6,000,000 to $8,000,000 already in its offshore operations, and that it will spend that much or more before it completes its present program for this year.

One of the many problems facing the oil companies that build structures in the open Gulf is the problem of removing the structure after operations cease. All pilings must be removed to a point at least 6 ft below the ocean floor, so as not to interfere with the fishing industry.

Pipe lines may be laid from the land to the offshore wells, but they, too, must be buried 6 ft below the ocean floor. As most of the Gulf bottom is covered with a soft oozy mud, it is possible the lines will sink deep enough in many places due to their own weight. Across shell reefs and sand bars, however, submarine trenches will have to be dug or washed out for the lines to be buried.

One thing is certain. Almost all the drilling and producing companies in the Gulf Coast area are now aware of the potential importance of offshore oil production. They are also aware of the importance of establishing adequate base facilities and getting to work as soon as possible on the choice prospects that are now under lease to them from the state of Louisiana. Many of these prospects may produce large quantities of oil from comparatively shallow sands, such as opened by Kerr-McGee et al. between 1500 and 1700 ft. Floating core drill-type rigs may be designed to search for such shallow production. In any event, the offshore search for oil will probably increase rapidly during the next three or four years. ★ ★ ★

**The blowout preventers on Humble's Grand Isle well No. 1 are arranged on the casing between the first and second decks of the platform, which are 80 and 94 ft, respectively, above the ocean floor. Fuel, water, and mud storage tanks are mounted on the first deck around the wellhead. The mud pumps, diesel engines, and pits are enclosed by metal walls (left).**



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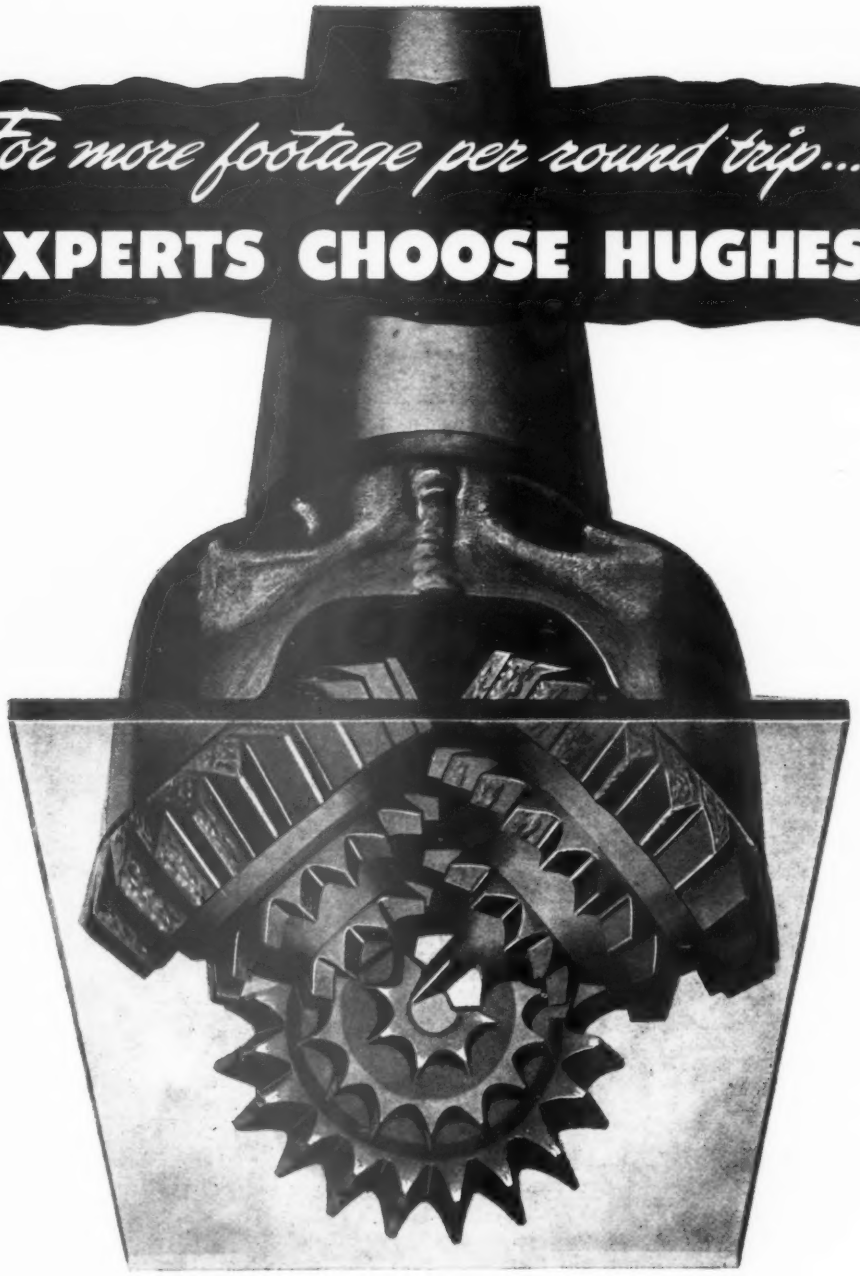

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# Industrial turbine maintenance

By G. W. ANDERSON, *Steam Service Supervisor,*

Westinghouse Electric Corporation

THE use of steam turbines for driving generating and mechanical equipment in industrial plants has developed rapidly during recent years. The size of the turbines used, the operating pressures and temperatures, together with the functions that they perform have all increased. The maintenance program therefore has become more involved and more important in order to assure continuity of service and realization of the high economic performance of which the equipment is capable.

It is not ordinarily possible to develop a maintenance organization in an industrial power plant comparable in extent with that in most of the large central station power plants. Frequently the maintenance work is performed by mechanics employed in the maintenance of any and all equipment throughout the entire industrial property. A group of specialized mechanics for maintenance work on the power plant equipment exclusively is not usually carried on the plant payroll. For this reason the engineer in charge of the power plant must develop certain key men in his plant organization who can direct the work of the general mechanics during a maintenance job. The general mechanic is usually a willing worker but he does not know the importance of many of the details in maintaining a turbine. Unless his work is supervised by someone who is familiar with the equipment, an incorrectly done maintenance job frequently results; not because it is poorly done, but because the man doing the job did not understand what was required. As industrial power plants develop in size and functions, a well trained maintenance supervisor becomes increasingly important.

A maintenance program is necessary. A systematic schedule of outages of the power plant equipment for inspection and repair must be set up. Frequently this is difficult in an industrial plant because of the fact that such outages must be scheduled to conform with the industry's production schedule. Nevertheless the power plant equipment must have its turn for inspection and, if necessary, repair. If this is not provided, unscheduled outages due to breakdown of the power plant equipment, are certain to result. Usually these enforced outages come at a time when they seriously impair the industry's production. It is up to the engineer in charge of the power plant to see that a schedule is set up for inspection and repair of the power plant equipment. And it is up to the management to cooperate with this engineer in arranging such a schedule. This seems logical and quite sensible, but many a costly outage of power plant equipment results because such a plan is not followed.

In setting up a maintenance schedule the engineer must keep a record of the condition of the equipment and make frequent reference to the operating log. This record need not be complicated but it must briefly cover the condition of the equipment as found during each inspection, including dates and materials used for any repairs required. It is not possible to arbitrarily set up a definite length of operating time between general inspections of all turbines. In some cases one year is satisfactory. In other cases these general inspections may have to come more often, whereas in others a period of two years or more may elapse between general inspections. The scheduling of a general inspection depends on the operating performance, as indicated by the log, and the conditions of the equipment as found during the previous inspection. In the case of a new turbine it is generally recommended that it be opened for complete inspection at the end of the first year of operation. This inspection may reveal developments such as deposit of foreign matter in the blading due to carryover from the boilers, erosion of blading due to moisture in the steam at the lower stages, accumulation of dirt or rust in the oiling system, or indication of mechanical distress of any of the internal parts. From this inspection the engineer can decide how long a period of operation is safe before the next inspection should be made, and schedule that inspection. If the conditions found are satisfactory, perhaps a longer operating period can be made before the next inspection; however, it must be borne in mind that inspections are made for the purpose of assurance that the equipment is in good condition, not for the purpose of making repairs.

By systematically checking the operating log the engineer can obtain considerable information for his guidance in setting up a maintenance schedule. Changes in pressures and temperatures almost always reveal a maintenance condition. The following are typical cases:

Stage pressures recorded at intervals under the same load conditions will indicate the cleanliness of the blading. If these pressures become greater under the same load conditions it is quite probable that carryover from the boilers is depositing on the blading and is restricting the flow of steam. This indicates that an outage must be scheduled to mechanically clean or wash out this deposit before the capacity of the turbine is seriously reduced or a mechanical failure results. Improvement in boiler feed water treatment has greatly reduced the danger of trouble due to deposits of carryover in the turbine blading. It is now seldom necessary to clean out large quantities of baked mud as was frequently the case during the early days of turbine and boiler development. Even with the modern methods of treating boiler feed water, however, and the use of high pressure and superheated steam, there are certain elements carried over with the steam that will create a deposit in certain sections of turbine blading. This condition must still be watched.

A general increase in lubricating oil temperature bears investigation. Frequently this is due to the oil cooler becoming dirty. A schedule for periodic cleaning of the oil cooler should be set up whereby it is kept reasonably clean at all times. The formation of scale on the water side of the oil cooler tubes usually accelerates due to the increase in oil temperature it causes. Frequently the cleaning is delayed too long and the oil temperature becomes dangerously high before action is taken. The excessive oil temperature contributes to higher maintenance cost of the turbine as well as damage to the oil. The matter of keeping the oil cooler clean is a fundamental of operation that it would seem unnecessary to mention here, but it is surprising how many plants neglect it.

A great many of the turbines used are designed for automatic extraction and/or non-condensing operation in order to supply steam at various pressures for industrial purposes. These turbines are equipped with regulators and control devices that must be maintained properly in order to give good service. By reference to the log and recording charts the engineer can determine just how well these pieces of apparatus are performing their function. Sticky valves or relays will become evident by the appearance of irregular recordings on pressure or flow charts. Worn linkage or failing pressure regulator diaphragms will show up as irregular speed or pressure control. If action is taken when these irregularities first begin to appear on the charts or records they can be eliminated by scheduling a regular inspection and cleaning of the control equipment. If this is not done an enforced outage may result from a control device becoming wholly inoperative. The replacement of pressure diaphragms, which are a part of automatic control equipment, should be given special attention. Don't wait until the diaphragms break and cause an outage before replacing it. Set up a schedule to renew all diaphragms at regular intervals. They are not expensive, but their failure due to lack of proper maintenance causes expensive outages.

Set up a regular schedule for the operators to test out the auxiliary oil pump and record the result of this test on the log. Set up a regular schedule to inspect the control valve and replace the diaphragm in the automatic regulator that brings this pump into service. This pump stands idle a large part of the time, and is much more subject to lack of atten-

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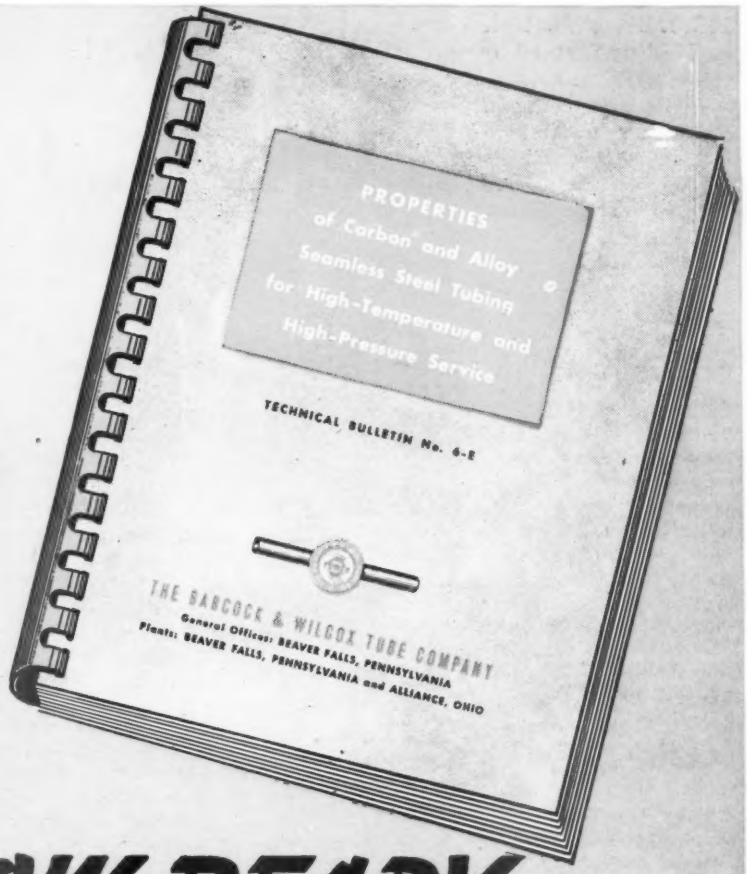


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FIG. 1. Deposits of scale on blading formed by "carry over" from boilers will cause reduction in capacity or mechanical damage if not removed periodically or eliminated at the source.

FIG. 2. Replacing a diaphragm that has had considerable service in an extraction pressure regulator is good insurance against failure in service.

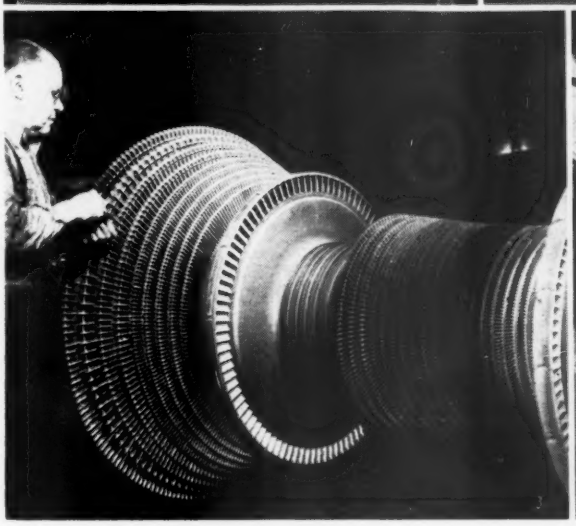

FIG. 3. Detailed inspection of blading assures that it is in good condition for the next operating period.

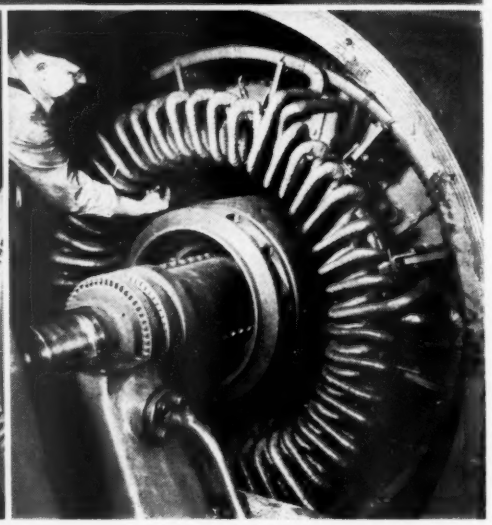

FIG. 4. Periodic inspection of insulation, lashing and blocking is essential in maintaining a generator in good operating condition.

tion than a piece of equipment that is continually in operation. Turbines have been seriously damaged because the auxiliary oil pump was in poor condition and failed to start when the turbine was being shut down.

Set up a regular schedule for checking the condition of the oil in the turbine lubricating system. Most oil suppliers will gladly analyze a sample of their oil from your unit. Oil does not wear out, but it does become unusable due to contamination with water and dirt. Examine the strainer in the oiling system regularly. It will give you an indication of any foreign material getting in the oil. The appearance of flaked babbit or bronze cuttings in the strainer, frequently enables the engineer to discover bearing wear before an actual failure occurs. This is a warning that demands action in checking operating conditions and perhaps scheduling an outage for complete investigation. Draw off a sample of oil from the bottom of the oil reservoir regularly. If water is found in the oil a campaign immediately should be started to find the source of the water and eliminate it. Most turbine oils do not stand up very long when contaminated with water. Frequently a small amount of water in the oil will cause rust formation on the iron parts of the oiling system. Gritty particles of rust from this source will be carried by the oil to the bearings and journals causing serious damage. In many cases the quantity of water in the oiling system will not be sufficient to definitely appear in a sample of oil taken from the bottom of the oil reservoir. Therefore, although the sample does not show any water, a second step in the investigation is necessary. Examine the underside of the cover of the oil reservoir, or the upper inside of a return oil line, which runs only partly filled with oil. If a gritty formation of rust is found at these locations, there is or has been water in the oil that vaporized and then condensed on these relatively cool iron surfaces. Many of the turbine oils now in use contain inhibitors for the purpose of preventing oxidation and corrosion. If a case of rusting of the interior of the oiling system develops, it is well to confer with the supplier of the oil and obtain his aid in eliminating the condition.

The development of excessive vibration is of course an indication of mechanical unbalance or misalignment, which demands immediate attention; however, in many cases this vibration may have been increasing over a long period of time, and earlier steps to eliminate it might have prevented an unscheduled outage. It is a good plan to measure and record the amplitude of vibration at regular intervals so that a small gradual increase in vibration can be noted and correction made during a regularly scheduled outage. Small weight or reed type vibrometers are available on the market for this purpose.

The work of making a general inspection requiring complete dismantling of the turbine, should be supervised by a representative of the manufacturer. With his experience he can pass judgment on the condition of blading, nozzles, valve gear, and other parts that may be showing signs of wear. These may require immediate repair or it may be that replacement parts should be ordered for installation during the next regularly scheduled outage. Here again the thought must be to predict required repairs so that they can be made before the condition of the equipment becomes so bad that a breakdown disrupts the industrial production.

In going back over the record of enforcing outages, it is almost always evident that the outage could have been prevented had certain maintenance or operating details been watched more closely. In many cases these were simple matters as outlined in the foregoing. The control of this is in the hands of the man supervising the maintenance and operation of equipment. By setting up a systematic record and schedule for making inspection, normal cleaning and minor repairs, he can eliminate a great many enforced outages, and in many cases, prevent costly major repairs. * * *

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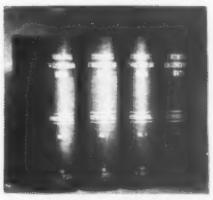

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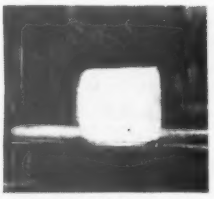

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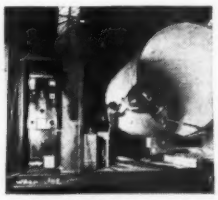

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# Engineering data needed in accounting problems

By RALPH U. MADDOX, Big West Drilling Company

EXCLUSIVE

PROGRESSIVE companies in this modern day petroleum industry are demanding more and more from the accounting department. Financial statements and cost studies considered appropriate and adequate 10 to 15 years ago are now as obsolete as an old jackshaft drawworks. The ever-increasing costs, both operating and capital, and increased tax burdens necessitate foresighted management giving greater attention to these items.

Modern cost accounting is the grouping of all expenditures by classifications in order to determine the true operating expense, inventory cost, or capital cost. The true cost of these items includes not only all direct cost, but also an adequate amount to cover overhead, depreciation, obsolescence, and depletion. Cost information should be accumulated in sufficient detail to determine the unit cost of an operation or job, such as lifting cost per barrel of oil, cost per 1000 cu ft of gas produced, cost per barrel of finished products, cost per foot of hole drilled and additional cost if well is cased, and cost per day of operating drilling rigs and workover machines.

The extent to which these costs should be classified depends to a certain degree upon the specific requirements or needs of the management. There are probably companies that keep costs in too great detail when considering the economics, but as a rule, most companies have an insufficient amount of cost detail and invariably both large and small companies neglect to include in their costs an adequate amount for overhead, depreciation, and other indirect costs. The form of presenting cost information to management is not nearly so important as the inclusion of all costs, both direct and indirect, and should be governed more or less by the need at hand. For example, top management probably would be interested only in a summary of the various unit costs, such as overall costs per barrel or per day cost, whereas the operating manager would probably require a more detailed cost statement, with the field supervisor presented only those costs over which he exercises a certain amount of control.

Overhead expenses are those indirect costs that are so often overlooked, such as office salaries and expenses, rent, officers' or managers' salaries or the equivalent thereto, traveling and entertainment expenses, advertising, cost of obtaining business and information pertaining to business, interest on monies borrowed, taxes, and many other similar items. These indirect overhead costs might, in many cases, amount to $1000 in connection with the purchase and installation of a pumping unit, $5000 for the purchase and initial rigging-up of a $300,000 drilling rig, and $60 per day per rig operated. Each operating function or capital expenditure must bear its proportionate part of the overhead burden.

The overhead of a company operating eight drilling rigs for a year might appear as follows:

| | |
|---|---|
| Total available operating rig days | 2920 |
| Net operated days (including overall time) | 1898 |
| Non-operated days | 1022 |
| Chief executive or owner (only amount allocated to drilling operations) | $ 20,000 |
| Drilling superintendent | 15,000 |
| Office salaries, expenses, and rent | 15,600 |
| Interest on $1,000,000 | 40,000 |
| Traveling | 12,000 |
| Entertaining and advertising | 6,000 |
| Legal and other professional expenses | 4,000 |
| Other expenses | 3,280 |
| Total | $115,880 |
| Cost per rig per day operated | $ 60 |

The actual interest expense would, of course, vary with the amount of owner's capital in the business. The example above is based upon a borrowed working capital of $500,000 and an unpaid balance on drilling equipment of $500,000—an instance that might apply to many drilling contractors. If the eight rigs mentioned consisted of two small, two medium, and four large rigs, all purchased in 1942 and before, plus the capital additions thereto due to capital replacements and modernization of the rigs, they would probably have a depreciated book value of approximately $550,000. If most of the rigs were purchased in 1946 and thereafter, the depreciated book value might amount to approximately $1,750,000, in which case the interest in the foregoing tabulation would be $80,000 per year, or an addition per rig per day overhead cost of $22. In this hypothetical case owner of the drilling company would have invested capital of $250,000 or more.

Capital expenditures for such items as refineries, pipe lines, oil and gas wells, leasehold and lease equipment, and drilling rigs normally should be spread over their economical useful life in the form of depreciation, obsolescence, or depletion. Normally, on the accounting records and for tax purposes, only the original capital investment, plus additions thereto, are recovered through depreciation, obsolescence, or depletion, but in cost studies and cost determinations some consideration should be given to inflationary or deflationary cost versus actual cost. In the present inflationary period, it would be unsound to sell crude oil based upon 1940 discovery costs plus only an amount to cover increased operating costs, because the depleted reserves cannot now be replaced for probably twice or three times the 1940 costs. Likewise, drilling cost estimates should be based upon approximate current drilling rig costs instead of the original cost plus current operating expense. These same principles are applicable to refineries, pipe lines, and other capital investments. In case of a deflationary period, three, five, or ten years hence, the then cost studies would have to consider the then prevailing costs, at least for competitive purposes.

Depreciation calculations might appear as follows:

| | |
|---|---|
| Cost of 12,000-ft rig—1942 | $175,000 |
| Cost of 12,000-ft rig—1948 | 350,000 |
| Cost of 12,000-ft rig—1953 | 150,000 |
| Estimated life in actual operated days | 1200 |
| Depreciation per day based upon cost: | |
| 1942 cost | $ 145 |
| 1948 cost | 291 |
| 1953 cost | 125 |

The contractor who has a 1948 rig must make a profit based upon $291 depreciation per day and the contractor who has a good 1942 rig should make a profit upon the same basis. The profit computed upon 1942 cost is not a true competitive profit from operation, but instead is a profit from appreciation of rig investment, due to an advantageous purchase date. In reality, this is the same as selling a residence that cost $7500 in 1942 for $15,000 and then having to purchase another one for relatively the same use for $17,500. Instead of making a profit of $7500 on the sale a $2500 loss was sustained, plus the amount of taxes paid upon the $7,500. (This illustration disregards depreciation on the original house cost). The operating profit for 1953 based upon a 1948 rig purchase will necessarily have to be scaled down to the $125 per day rate in order to meet competition; in other words, take the deflationary loss and start with a new base. The procedure, as outlined herein relative to depreciation, no doubt deviates from the thinking of many accountants on the subject of depreciation, but the principle outlined will help the company to stay in business and be able to purchase new equipment when required; otherwise, in many cases, it might be doubtful whether the company could continue operating.

Particular stress should be given to the item of obsolescence, which, in the case of power drilling equipment, refineries, and gasoline plants, together with many other types of equipment, is taking place at a rapid pace each day and in many instances is far greater than the physical depreciation.

Due to the relatively short economical life of drilling equipment, refineries, and many other types of equipment, because of the rapid depreciation and obsolescence, they might be likened in some degree to merchandising. If a shirt cost $1 and the present cost is $2, then a 40 per cent markup should be on the $2 instead of $1, but if the reverse were true and the cost was $2 and the present cost $1, then competition would force

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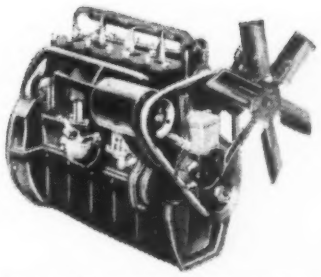
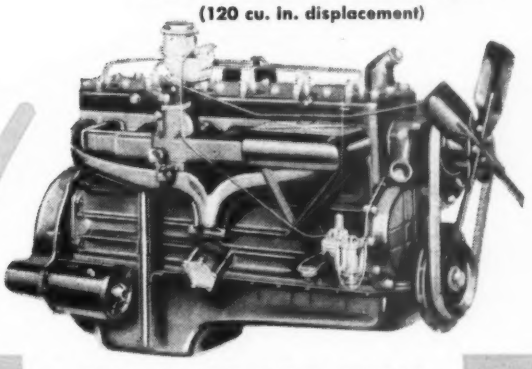


Ford 120 Four Cylinder Industrial Engine
(120 cu. in. displacement)



Ford 226 and 254 Six Cylinder Industrial Engines (226 and 254 cu. in. displacement)

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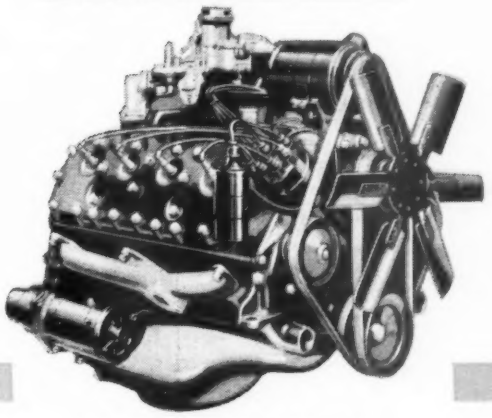

Ford 239 V-8 Industrial Engine
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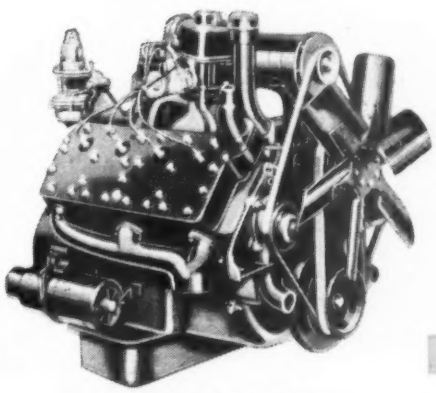

Ford 337 V-8 Industrial Engine
(337 cu. in. displacement)

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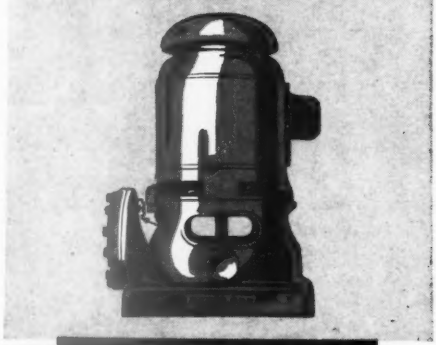

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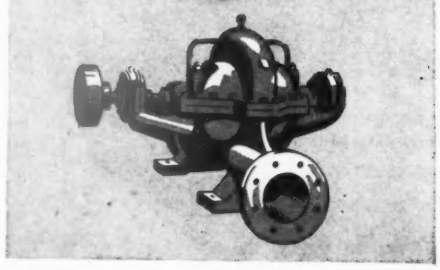

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the 40 per cent makeup to be applied on the $1 present cost. Good management and competition demands that to a certain degree this principle in good merchandising be followed in any type of business or industry.

The net profit for federal income tax purposes is not necessarily the net profit reflected by the books and records of the company, nor the net profit determined by cost studies as previously outlined. The many complications of the federal income tax laws and the high prevailing rates demand careful consideration at all times of the tax liability, as this might determine whether the company survives or ceases operations. Taxwise, which also means profitwise, each deal or transaction should be set up and handled so that a minimum amount of tax will be paid. In many cases, a deal might be slightly changed to result in a substantial difference in the tax liability. Many deals that might be considered good would, in reality, be poor ones when the tax liability is determined and vice versa. As taxable income does not always coincide with the income based upon good, conservative accounting principles, it is sometimes necessary to maintain partial duplicate records to account for these differences.

Tax accounting for the petroleum industry has many peculiar and complicated problems and therefore requires special attention and handling. Depreciation is normally calculated on the lapse of time; however, in many cases, depreciation rates are based on the units to be produced or manufactured. Conservative depreciation, obsolescence, and depletion rates might differ widely from the rates established by the taxing authorities, necessitating duplicate calculations.

Well cost is divided chiefly into two major classifications, tangible and intangible costs. Tangible cost includes such items as casing, tubing, christmas trees, pumping units, and other similar items usually having a salvage value. These items are capitalized and recouped through depreciation and obsolescence. Intangible well cost includes items normally having no salvage value such as drilling cost, labor, transportation, testing, surveying, coring, cement and cementing, and items of a similar nature. These items of intangible well cost may be charged to expense when incurred or they can be capitalized and recovered through depletion, at the election of the individual company. The election once made must be followed in all subsequent years. All companies were given the privilege of making a new election for the first taxable year beginning after December 31, 1942, at which time practically all companies elected to expense intangible well costs currently as incurred. Good accounting practices dictate that items of intangible well cost be capitalized and the costs recovered over the life of the properties, and many companies follow this procedure in their accounting records, but in the preparation of their tax returns these intangible costs are considered as expense. The option referred to above does not apply to intangible lease cost, which is a cost capitalized the same as tangible well cost and tangible lease cost and is recovered through depreciation.

Depletion is the using up or wasting away of an asset, and the company should recover its cost over this period, which is usually based on the estimated units to be produced or manufactured. Leasehold cost and intangible well cost are depletable items and are recovered over the life of the properties. Oil and gas producing companies, as well as most other mining companies, are given the privilege of calculating depletion on the basis of cost or on a statutory basis for tax purposes. In the case of oil and gas properties, the statutory depletion is 27½ per cent of the gross income from the properties. This depletion, however, shall not exceed 50 per cent of the net income from the properties computed without allowance for depletion. Due to the 50 per cent limitation, it might be taxwise to defer the drilling of additional wells upon a property until a subsequent tax year, as for example:

| | |
|---|---|
| Estimated gross income for 12 months | $300,000 |
| Estimated operating expenses for 12 months | 10,000 |
| Operating profit | $290,000 |
| Intangible well cost first 9 months | 125,000 |
| Profit after intangible well cost | $165,000 |
| Depletion—27½ per cent of $300,000 | 82,500 |
| Profit subject to tax | $ 82,500 |
| Profit after intangible well cost restated from above | $165,000 |
| Additional intangible well cost last 3 months | 165,000 |
| Profit after intangible well cost | $ —0— |
| Depletion allowable | —0— |
| Profit subject to tax | $ —0— |

In this illustration, no taxes would be due if additional wells with intangible well cost of $165,000 were drilled; however, the depletion allowance of $82,500 would be forever lost. If the additional drilling could be deferred until after the current taxable year, the company would receive the benefit of the depletion allowance in the current year, and the additional wells could be drilled in the following year probably without the application of the 50 per cent depletion limitation. The taxes for the two-year period probably would be considerably less if the drilling were deferred. Due to several variable factors, the advisability of deferring the drilling and the tax savings would necessarily have to be considered in each individual case.

The privilege of currently expensing intangible well cost and the statutory allowance for depletion might, at first thought, be considered as a tax advantage, but when considering the hazards of drilling operations and the enormous cost of new discoveries, together with the price structure, there is no appreciable advantage given to the oil industry over that of other industries.

In conclusion, management should continually study operating cost and capital expenditures in the light of present-day costs versus actual costs and the effect of the tax burden upon the operations. These studies should be the influencing factor in determining current operating procedure, dividends, expansion, and investment policies. ★ ★ ★

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## IN SUCKER ROD WIPERS *gives you a clean string of Rods*

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**CODE: *SUBAGENT***

(Specify Thread Connection Desired)

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The main wiping rubbers are sealed in the body so that no oil leaks on the floor. The rubber grips the sucker rods in such a manner that the rods are wiped clean no matter how fast the string is pulled. They will seal against all but excessive gas pressures and will allow oil to flow to tank if the well makes a head.

Special spark proof lids for the Paraffin Wiper are available at a slightly higher cost. Install one of these Patterson-Ballagh Sucker Rod Paraffin Wipers on your rig today and give your rods a clean wipe the next time they are pulled.

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**Code: *PRAETOR***

**Code: *REFACE***

The two main D-25 rubber wiping elements, code: PRAETOR, have been strengthened to allow for expansions from ½" to 2⅜". Below these, is the cone-shaped rubber element, code: REFACE, which acts as a one way valve. This wiping element prevents the paraffin that has been stripped from the rods falling back into the hole.

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# Automatic welding speeds pipe line work

By G. L. REVELL* and C. G. HERBRUCK†

To speed the welding of the miles of joints in large pipe line jobs, the Williams Brothers Corporation of Tulsa, Oklahoma, are putting into operation

**EXCLUSIVE**

fixtures designed to use "Lincolnweld" equipment and the hidden arc, automatic, deep flux welding.

Two completely automatic pipe welding fixtures have just recently been completed for the Williams Brothers Corporation by the Cal-Metal Corporation of Torrance, California. The fixtures will make automatically the circumferential welds in pipe up to 31-in. diam in size. The fixtures have a capacity for welding a total of 4000 ft of pipe in an 8-hr day. In use, the fixture welds 30-ft lengths of pipe into 90 or 150-ft sections, which are then trucked to the line where they are tied in with the conventional welding techniques.

The "Lincolnweld" process that is used in welding the pipe is an automatic metallic arc-welding process. Granular flux is deposited on the joint to be welded, deep enough to cover the completed weld. Bare metallic electrode is power fed into the blanket of flux, its rate of feed controlled automatically for arc length. Direct current supplied by a welding generator produces the hidden arc between the electrode and the joint. The resultant arc heat fuses the electrode and the parent metal producing the weld. Flux, adjacent to the arc, melts, floats on the surface of the molten metal, then solidifies as a slag on top of the weld. As the arc and the molten metal are blanketed by flux at all times, the weld metal is completely protected from contact with the air, assuring the maximum quality of weld and making possible the use of extremely high amperage. The speed of welding is high and only a few skilled operators are needed, whereas exact control of the process is maintained at all times, resulting in identical high quality welds at each joint.

One of the fixtures built for the automatic welding of pipe can be seen in Fig. 1. For welding, the pipe is put on rollers between two rails. The rails are approximately 220 ft long. Operating on the rails are two pairs of cars that are built and operate as integral units. The two forward cars (Fig. 2) of each pair are the control cars from which the entire operation is push button controlled. On the control car are the "Lincolnweld" automatic heads and the vacuum flux recovery units. Suspended below the control car is the operating end of the expander and aligning mechanism, which exerts from 700 to 50,000 psi pressure. The expander heads are attached to the rear cars by a long mandrel through which the hydraulic pressure lines to the head are run. The length of the mandrel can be seen extending back in Fig. 5. On the rear cars of each pair (Fig. 3) are the cable reels that take up or play out the power cables coming from the diesel electric plants that supply each unit. Power for the units on the car is taken off by collector rings. Also on the rear car are the 1200-amp welding current generators, and the motors and pumps for the controlling hydraulic systems and the cooling water. Each pair of cars is approximately 35 ft apart and can be operated forwards or backwards from either of two operator positions.

The steel skidways at the side of the

*G. L. Revell, welding engineer, The Lincoln Electric Company, is at 1500 Calzona Street, Los Angeles, California.

†C. G. Herbruck is assistant to the secretary, The Lincoln Electric Company, Cleveland, Ohio.

**FIG. 1. One of the fixtures being built to adapt automatic welding to pipe line work. From left to right along fixture bed are: Power car, two control cars and another power car behind shed.**

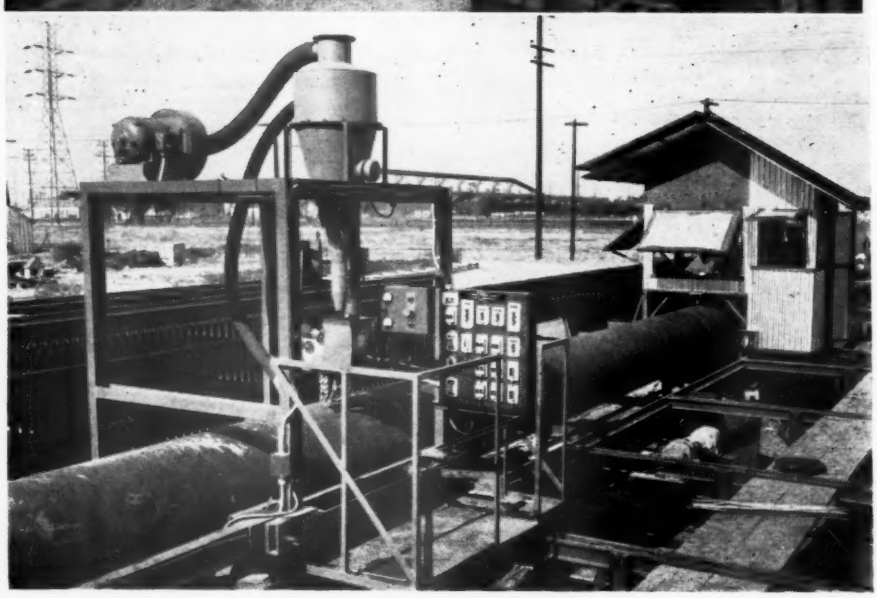

**FIG. 2. Close-up of control car showing automatic head and vacuum pick-up unit. Operation of heads, pipe rollers, and car travel are controlled from the panel shown.**

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# Smooth, Easy Closing

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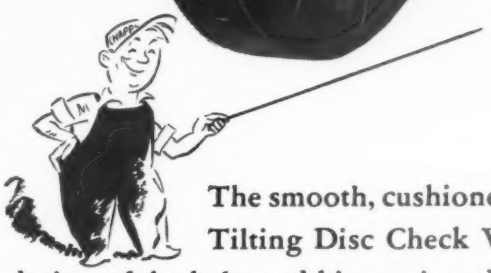

The smooth, cushioned closing of Chapman Tilting Disc Check Valves is based on the design of the balanced hinge-pinned disc. When the valve is open, the disc rides evenly in the flow. On closing, the disc seat drops into contact with the body seat *easily* and *quietly*—cushioned by the effect of the stream against the short flap. Vibrations and destructive stresses in pipe lines are thereby reduced.

With this unique check valve, maintenance costs are cut, and head losses are reduced as much as 65% to 80% over those experienced with conventional type check valves.

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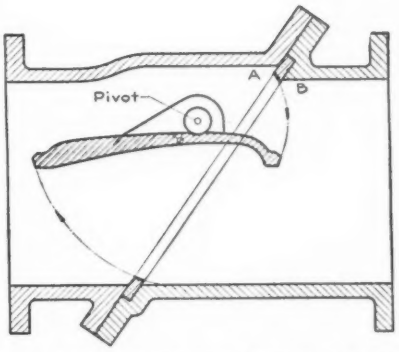



Cross-section of the Chapman Tilting Disc Check Valve illustrating the way that the balanced disc is supported on the pivot, with arrows showing the travel of the disc. A feature of the design is that the disc seat lifts away from the body seat when opening, and drops into contact when closing, with no sliding or wearing of the seats.

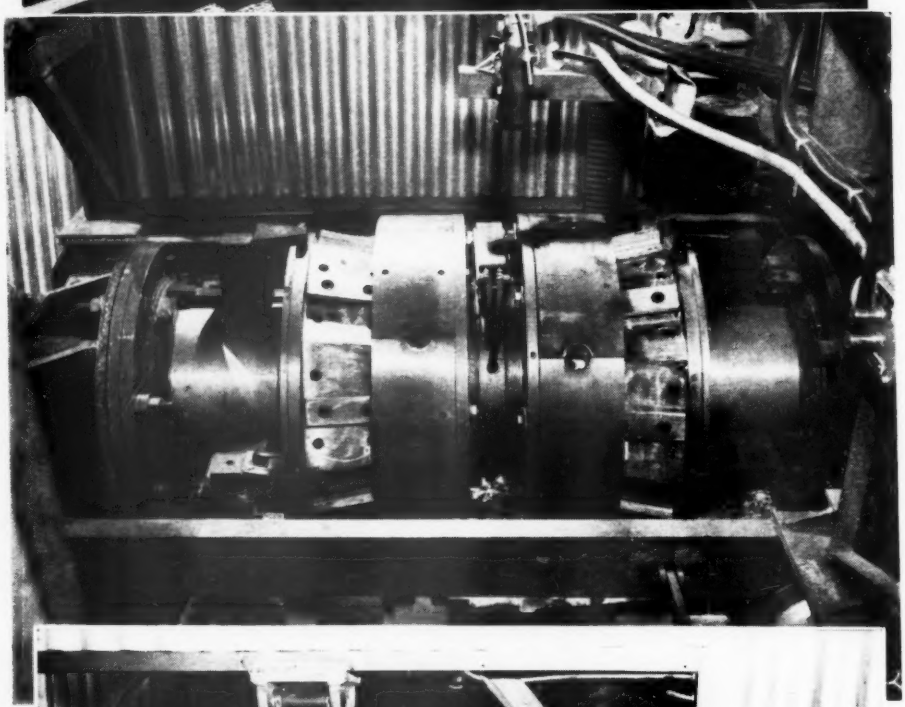
**The Chapman Valve Manufacturing Company**

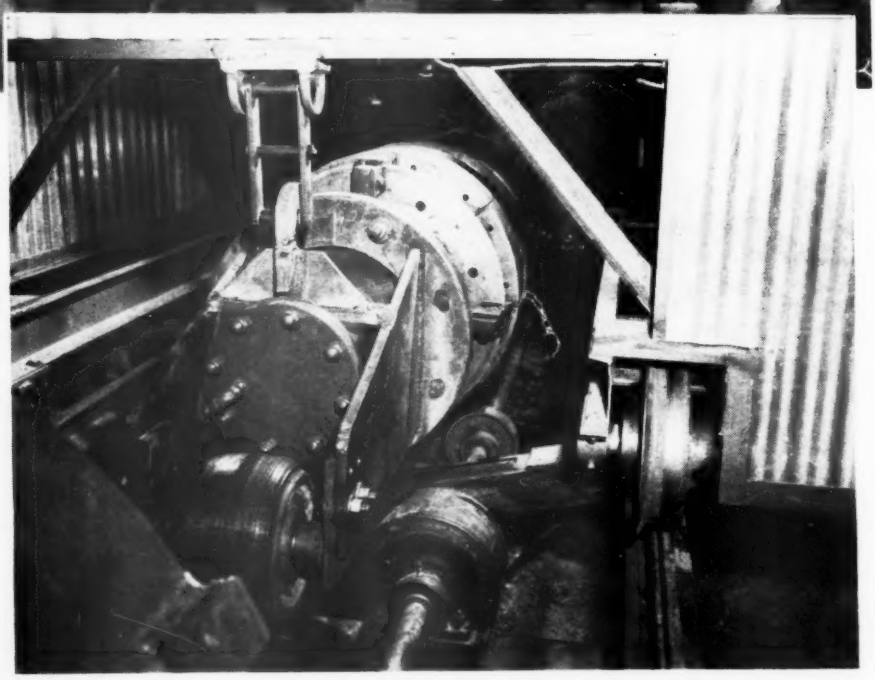
INDIAN ORCHARD, MASS.

FIG. 3. Close-up of the power car showing welding current and auxiliary power generator. Large panel contains fuses and relays.

FIG. 4. Expander and aligning mechanism head suspended below control car. The water cooled copper backup shoe is in center of photo.

FIG. 5. Head of expander and aligning mechanism shows length of mandrel back to rear power car.





fixture holds two miles of stacked pipe. To begin the welding cycle, the cars are run out to the extreme ends of the fixture. Hydraulically actuated arms push three lengths of pipe onto the rollers. The cars are then moved toward the center, ramming into the pipe the expander mechanism as they proceed. The operating end of the expander is dropped from the hooks holding it below the control car, and rides on a guide wheel as it is pushed farther into the pipe. (See Fig. 4.) The cars come in to where the two joints are to be made and each car expands the inside half (Fig. 4) of the expander, which firmly clamps to the center one of the three pipes. The expanding mechanism moves on the mandrel, and the inside expander, copper back-up shoe, and head are positioned and located for welding. The outside clamps of each unit are then expanded, and the outside pipes moved into butt against the center pipe to make the joints for welding. The pipes can be raised off the rollers by arms so that they can be moved forward by the action of the expander sliding on the mandrel.

By the action of the expanders the pipes are butted and the diameters perfectly aligned for welding. The copper back-up shoe is then raised into the welding position.

The controls are relayed so that the start buttons on both cars must be in before the welding operation will start. The pipe is rotated at speeds in excess of 20 in. per min, while the heads are depositing the welds using currents in excess of 600 amp. The two welds are made simultaneously, completing a 90-ft section, including fit-up and expansion, in less than 12 min.

Although automatic hidden arc welding has been used in making the longitudinal seams in pipe, it has only been during the last year that its advantages have been applied to the laying of pipe lines. New records are expected with this equipment. Two automatic fixtures working two 8-hr shifts can weld five miles of pipe. The number of manual welds to be made is greatly reduced. This, besides contributing to the speed of the job, also relieves the manpower problem, a problem that is particularly important in working overseas.

The Williams Brothers Corporation is planning at present to put five such units into operation. ★ ★ ★

*Isn't it about time*

**central heating** *to get on with it*

*as a common sense means of Fuel Conservation?*

The ability of the United States to assure its security and maintain its position of leadership in the world depends ultimately upon its fuel reserves. Misuse of these vital resources can mean decline and disaster.

Nearly 99% of this country's known fuel reserves is in the form of coal. The United States has all the coal it needs for many generations to come. The reserves of other fuels, however, are being exhaused at an alarmingly increasing rate, largely because they are being used to do certain jobs which coal can do as well or better.

One of the major causes of this unsound state of affairs is the public demand for convenient, "push-button" heat that is clean, efficient and labor-free. To meet this demand, non-solid fuels are being extravagantly misused in ordinary heating in spite of the fact that they are urgently needed for other essential purposes. Coal, properly used, can provide everything the public demands in the way of "push-button" heat.

*Central Heating is the solution—using steam or hot water distribution from centrally located heat generating plants serving entire communities.*

For the vast majority of people in this country space heating is by far the most costly of utility services, indeed more costly than all other essential utilities combined. Certainly, an economic system which has been able to provide our communities with water, sewers, gas, electricity and telephone service—certainly, that same economic system is no less able to provide this even more basic service of Central Heating at a cost attractive to consumers and at a profit equally attractive to investors.

With a realistic appraisal of our fuel resources in the light of conditions which exist in the world today, and with the end in view of a better and stronger United States of America, secure in a way of life made possible by private enterprise fostered and bulwarked by governmental institutions—*isn't it time to get on with it now?*

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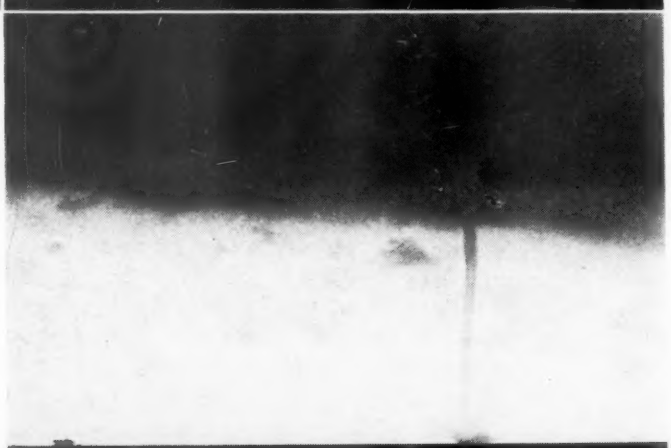

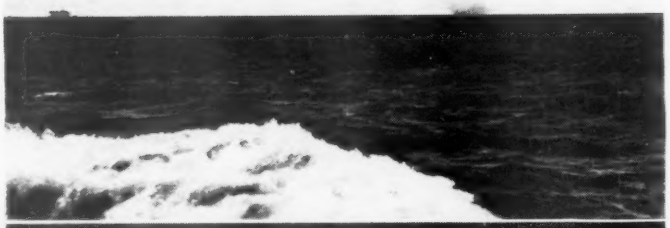

# Weather is Gulf drilling problem

By K. MARSHALL FAGIN, *Field Editor*

WEATHER plays its part in the set of new drilling problems arising from overwater drilling in the tidelands of the turbulent Gulf of Mexico. Visitors to the Humble drilling barge in May saw seven waterspouts at one time (not 17 as reported in a recent issue of Life Magazine).

**Above, the rotating funnel of a waterspout dropped slowly from a dark storm cloud and whipped up the water of the Gulf of Mexico as our 83-ft air-sea rescue ship cruised toward Humble's giant drilling platform, which is about 8 miles out from Grand Isle, a low sandy island along the shore of the Gulf of Mexico, about 45 miles south of New Orleans.**

**To the right the funnel of another waterspout formed between our boat and the Humble drilling platform. This one curved around menacingly in the stiff breeze from the East that preceded a short but heavy rainstorm.**

**Two more waterspouts formed off our port side (center). The funnel at the right was about ½ mile from our boat and was developed more fully than the one on the left (just to right of the incompleted platform being built for drilling a shallow test to the top of the salt dome).**

**The waterspout at the left changed its course and began heading for us as this photograph was taken. Our skipper promptly changed our course and ordered the hatches battened down as the windstorm and spray began to whip our boat around like a cork. As the last waterspout of the afternoon moved on toward the West, and the skipper headed our boat again toward the giant platform, right, the rain began to fall in torrents.**

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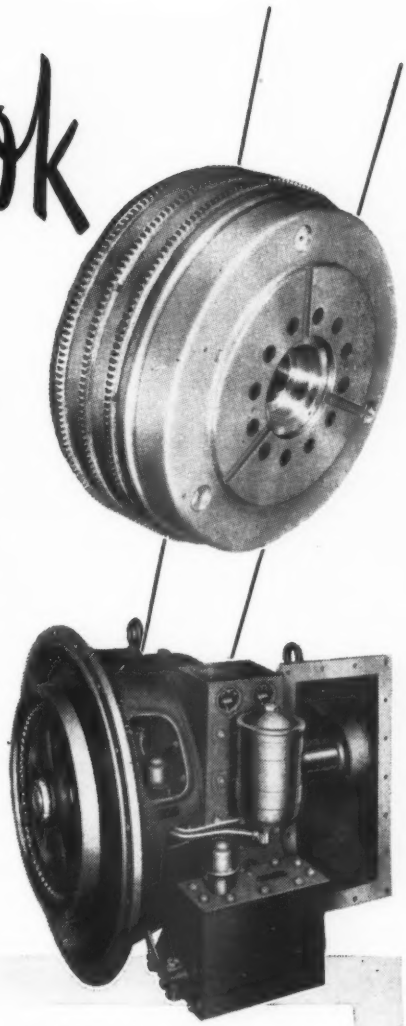

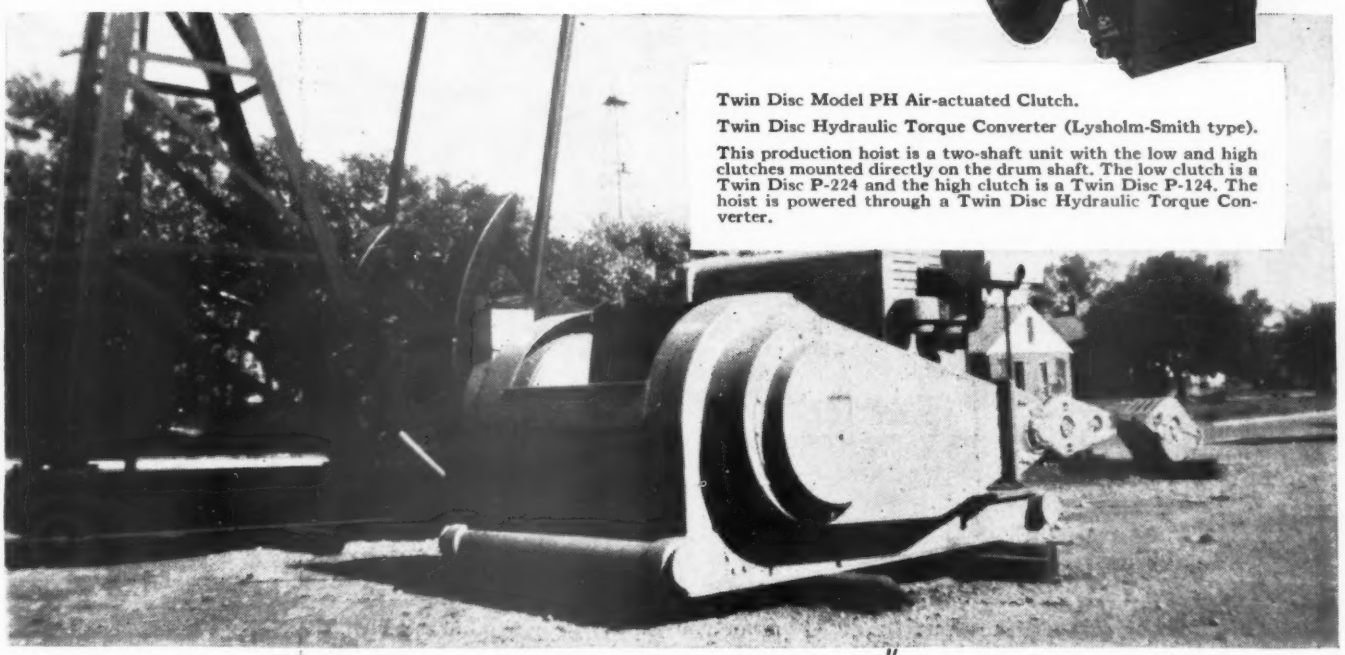

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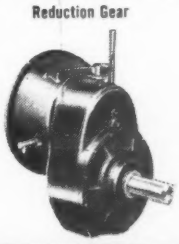

Reduction Gear

Machine Tool Clutch

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Marine Gear

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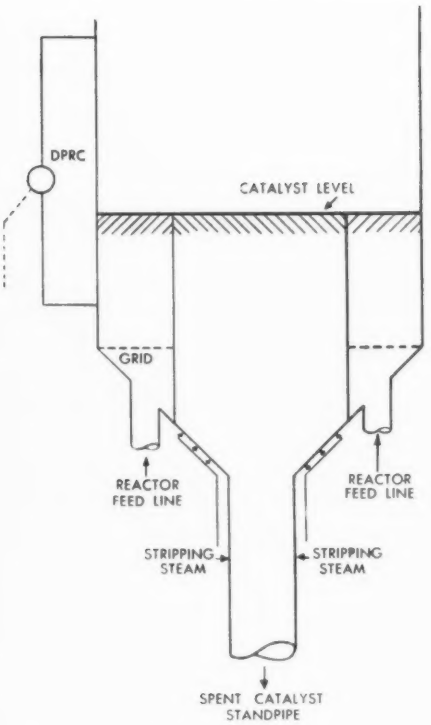



FIG. 1. Single-level operation.

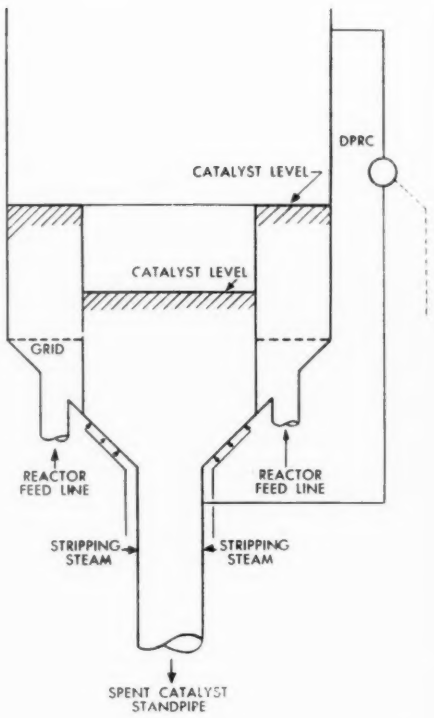



FIG. 2. Two-level operation.

ONE-THIRD of the gas oil feed stock for the three fluid catalytic cracking units at the Cities Service Lake Charles, Louisiana, refinery is prepared by propane deasphalting reduced crude. The deasphalting operation is controlled to produce a heavy deasphalted gas oil in order to maximize catalytic cracking unit feed stock availability. Only 2 per cent of the crude is normally yielded as asphalt. As a result of such operation the deasphalted residual gas oil tends to produce high catalytic coke yield and contaminates cracking catalyst rapidly.

Experience at Lake Charles shows that with conventional fluid unit operating procedures about 10,000 bbl a day of this heavy residual gas oil can be blended into the total feed stock charged to one cat cracker. As the refinery crude rates were stepped up the production of this gas oil increased to 20,000 bbl a day, which made it necessary to blend the deasphalted gas oil into the feed stock of two catalytic units, thus increasing the rate of contamination on two beds of catalyst.

Fortunately, however, the Lake Charles operators developed a modified stripper that resulted in their again being able to charge the deasphalted gas oil production to one unit. Fig. 1 shows the conventional downflow unit stripping arrangement and Fig. 2 indicates the Cities Service modification. The magnitude of the improvement is shown by the following data:

| Feed stock, bbl per stream day | Conventional | Two leve |
|---|---|---|
| Deasphalted oil | 10,300 | 20,205 |
| Distillate gas oil | 20,923 | 10,087 |
| Total feed | 31,223 | 30,292 |
| Carbon residue on feed stock, weight per cent | 0.95 | 2.06 |

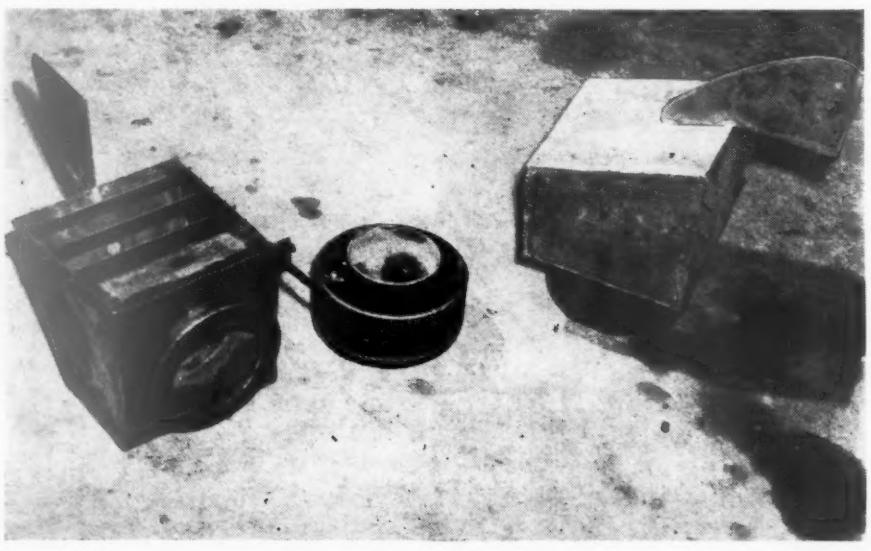
Several other major companies have met with similar success with the two-level operation. The cost of making the conversion is negligible. ★ ★ ★

P 625.

# REVOLVING VENT FOR PIPE LINE HEATERS

By O. C. IRVINE

Illustrated in the accompanying picture is a novel device, designed by Section Foreman Frank Roberts and built with the assistance of crew members of United Gas Pipe Line Company's Crowley section in the company's Southwest Louisiana district. It is a wind-directed vent, built of scrap materials, to prevent strong winds from blowing out the fires in the direct heating units installed at points of regulation to forestall hydrate formation in a natural gas pipe line.



Now ready for practical tests, the vent will if successful, serve to eliminate one of the worries of a pipe-line maintenance crew. It is typical of the natural inventiveness of maintenance men through which they utilize means and materials readily at hand to make their tasks easier and more effective.

The homemade vent, applicable only to direct type heaters (those that apply gas flame directly to the line pipe), is fitted on top of the heater flue. It rotates so that the louvers always face away from the wind. Thus, ample draft is provided while the flue is shielded to prevent strong gusts of wind or driving rain from extinguishing the heater fire.

As shown in the illustration, the complete unit is on the right. On the left, the apparatus is dismantled to show the principal parts, both the vent and the base it revolves on. It will get its initial try-out at United Opelousas, Louisiana, city gate station where considerable heater trouble, due to strong winds, has been experienced. ★ ★ ★

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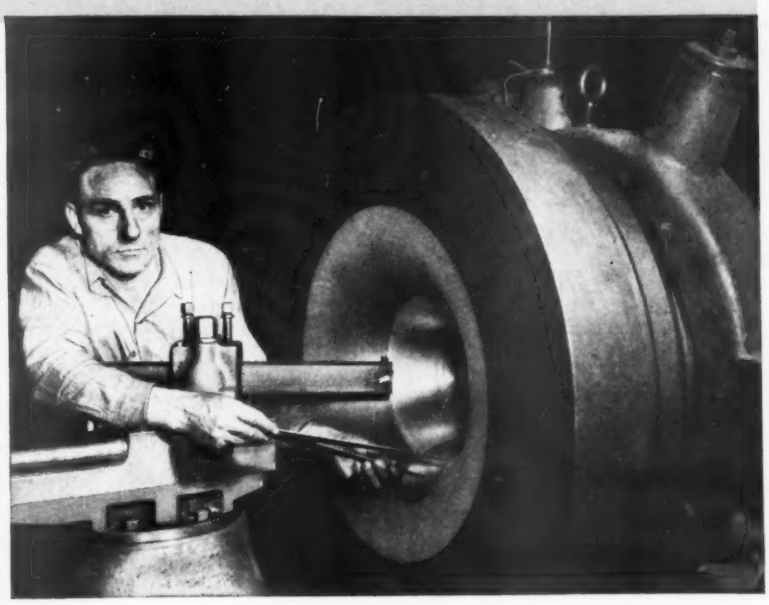
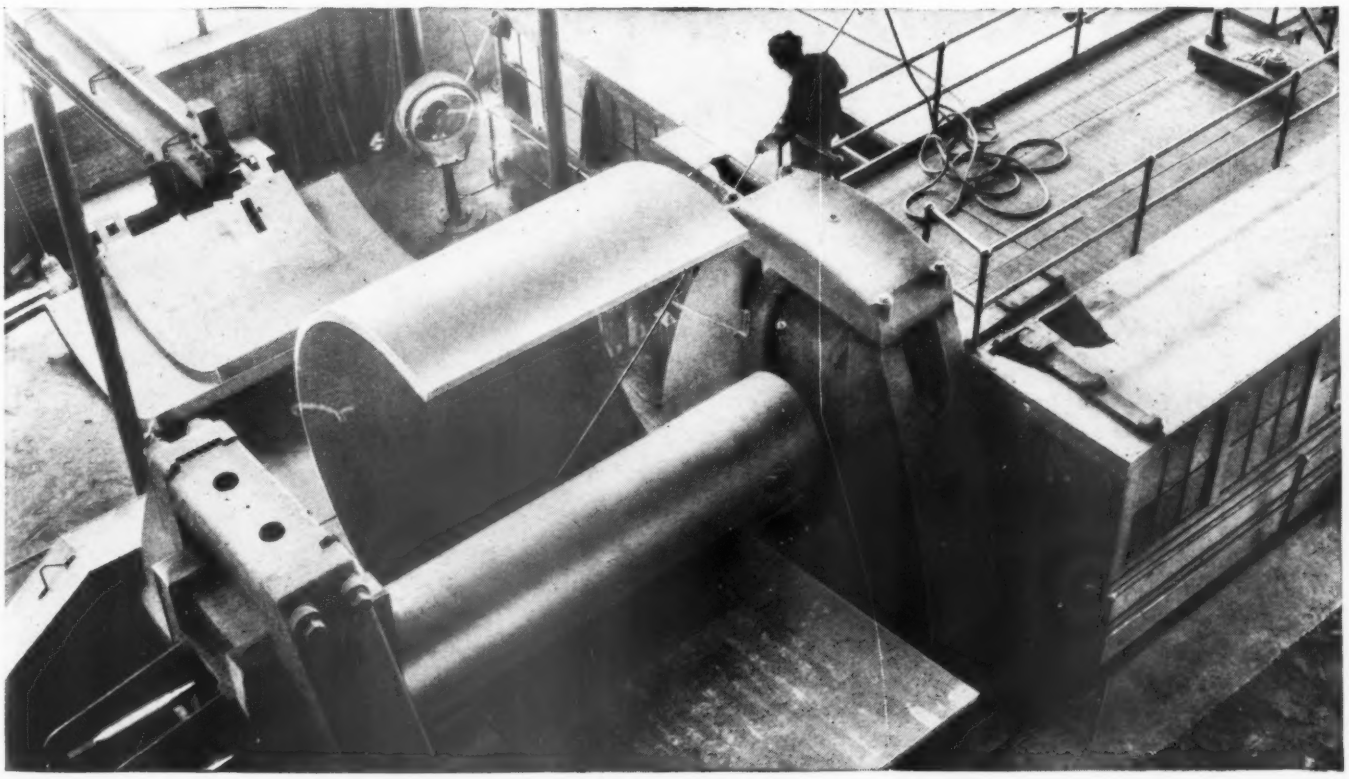


**TAILOR IN STEEL.** Since 1923 Jacob Strand has machined the parts of hundreds of SMITHway Vessels which are now in service all over the world.

**HEAVYWEIGHT CHAMPS?** Frankly, we don't know. But these particular heavy rolls come in handy when 8,000,000 lb. of pull-down are needed to shape heavy steel plates.



# The relation of nozzle fluid velocity to rate of penetration with drag type rotary bits*

By J. P. NOLLEY, GEORGE E. CANNON, and DOUGLAS RAGLAND
Humble Oil and Refining Company

● **Abstract.** This paper represents a progress report on a long range study of drilling technique being carried out as a research project by the Petroleum Engineering Division of Humble Oil and Refining Company. The data presented are concerned chiefly with the relationship of hydraulics to rotary drilling. Observations recorded on 26 wells in Texas and Louisiana while drilling 106,800 ft of hole with two-bladed drag type bits show that within wide limits of constant rotary speed and maximum effective bit weight, rate of penetration is directly proportional to the product of rate of circulation and bit nozzle fluid velocity. As bit nozzle fluid velocity may be varied at considerably less cost and power than rate of circulation, maximum rates of penetration are obtained when most of the available hydraulic horsepower, including that required for a reasonable flow in the drill pipe annulus, is converted into velocity energy at bit nozzles. Simple charts for use in arriving at the optimum size bit nozzle for any drilling rig assembly are included with the paper, and the design requirements for bits adapted to high nozzle fluid velocity drilling are presented.

● **Introduction.** Some style of blade type bit has been used with the rotary drilling method since the rotary was first employed to drill for oil in 1895.[1] Undoubtedly, there has been considerable specialized study of the factors that affect rate of drilling with blade type bits, but a survey of the published literature indicates that most of the work has been limited to the improvement of blade materials. With few exceptions, the papers on drag bit drilling technique[2] are, in large part, based on opinion as the engineering data are seldom presented.

The purpose of this study is to evaluate factors other than blade materials that affect the rate of penetration with drag type rotary bits with particular emphasis on the relationship of hydraulics to drilling technique.

The conclusions and recommendations presented in this paper are based on engineering data obtained at 26 wells while drilling 106,800 ft of hole.

● **Trend of drag bit drilling.** The use of drag type bits is limited to the drilling of soft to medium hard formations composed mainly of the softer shales, sandstones and limestones. Development of the bit has consisted principally of those improvements in material and design features that allow a maximum amount of hole to be drilled between renewals of the cutting edges.

Drag bits used in early day rotary drilling were usually hand-forged and crudely heat-treated at the drilling site. Present day commercial types of drag bits, as illustrated by Fig. 1, are equipped with heat-treated, drop-forged steel blades. Tungsten carbide inserts applied to the face of the blades and to the reaming edges account for a tremendous increase in footage per bit in comparison with the early designs. Other improvements, such as replaceable blades that prolong bit body life have also been developed.

Drilling fluid nozzles in most current bit designs are replaceable steel alloy tubes, usually one per blade, welded into the bit body. Although some drillers have maintained a preference for nozzles of small bore, the materials used for nozzle tubes have not been adequate to withstand the abrasive action of drilling fluids at high velocities. Consequently, the trend has been to employ nozzles of a bore sufficiently large that destructive fluid velocities are not attained even with the larger circulating pumps. Current practice embodies the use of nozzles ranging from 7/8 in. to 1¼-in. bore with resultant nozzle fluid velocities of from 50 to 200 fps and with apparently little thought being given to the possible effect of nozzle fluid velocity on rate of drilling.

The largest quantity of drag bits are constructed in the two-blade style; however, drag bits with three blades are in common use. Four bladed drag bits have been used to a limited extent.

● **Hydraulics and drag bit drilling.** In the course of drilling technique development work conducted during 1943 and 1944 with a Humble Oil and Refining Company drilling rig in southern Louisiana, it was noted that rate of drilling with drag type bits is roughly proportional to rate of circulation. On the basis of this work, which was conducted while drilling two 10,000-ft wells, a survey was made of the circulating system on Humble's drilling rigs to determine the best means of circulating a maximum volume of mud with available equipment. A logical means for circulating a greater volume of mud without adding to rig equipment was the substitution of 5-in. OD, 19.50-lb-per-ft internal upset drill pipe equipped with 4½-in. internal flush tool joints[3] for the 4½-in. OD external upset, internal flush, 16.60-lb-per-ft drill pipe that was in common use at that time. As shown by test data in Fig. 2, the

FIG. 1. Commercial type two-way drag bits.

*Presented before Southwestern District API Division of Production, San Antonio, Texas, April 14-16, 1948.

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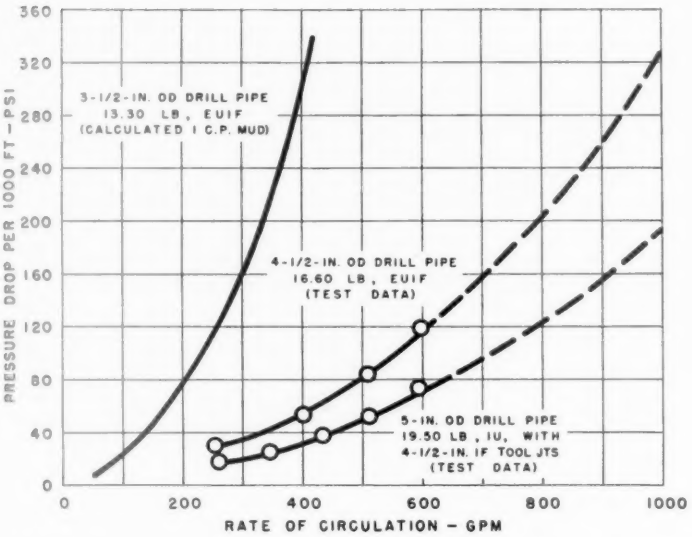


**FIG. 2. Pressure drop through drill pipe (natural shale mud—viscosity under flow conditions not determined for test data—mud weight 10.3 lb per gal.**

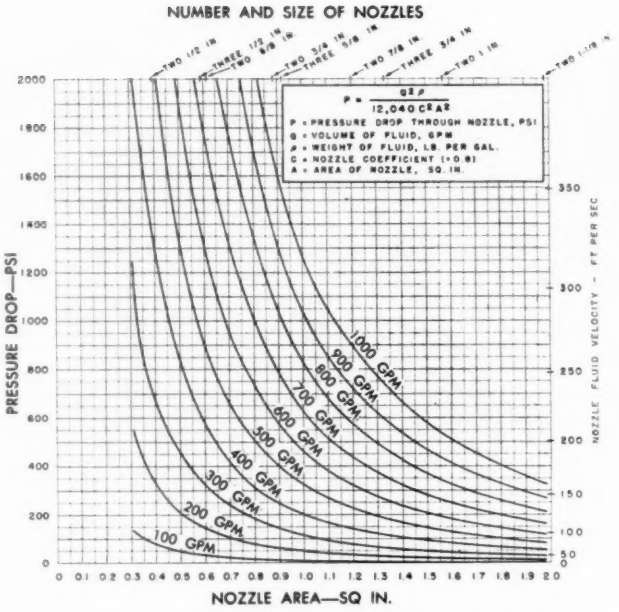


**FIG. 3. Calculated pressure drop through drilling bit nozzles (mud weight, 10.0 lb per gal).**

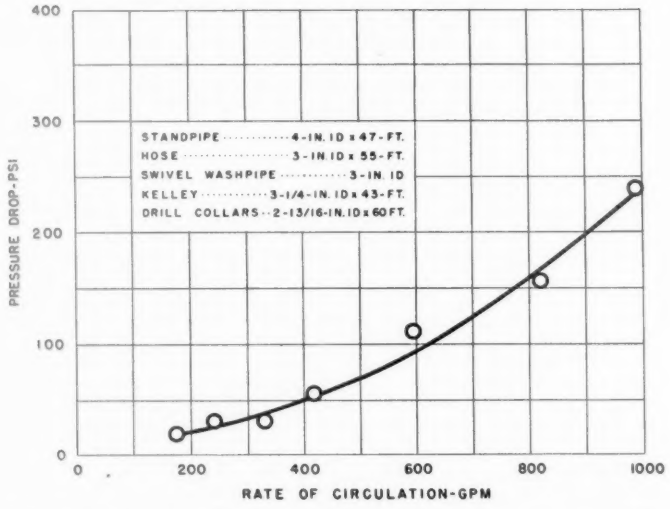
STANDPIPE ..... 4-IN. ID x 47-FT.
HOSE ..... 3-IN. ID x 55-FT.
SWIVEL WASHPIPE ..... 3-IN. ID
KELLEY ..... 3-1/4-IN. ID x 43-FT.
DRILL COLLARS .. 2-13/16-IN. ID x 60 FT.
PRESSURE DROP-PSI
RATE OF CIRCULATION-GPM

**FIG. 4. Pressure drop through surface connections (natural shale mud-viscosity under flow conditions not determined—mud weight 10.0 lb per gal.**

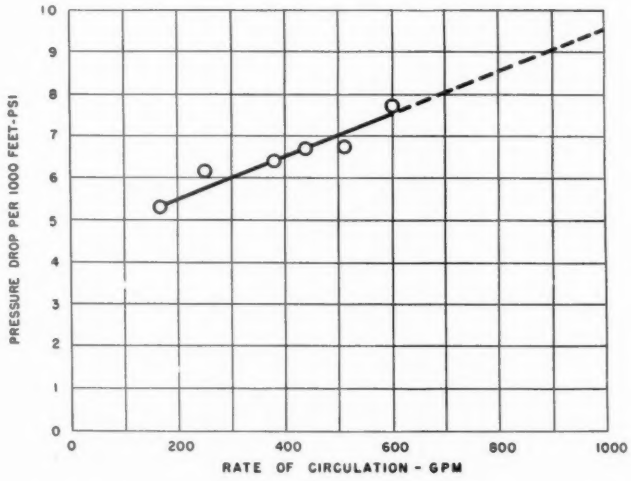


**FIG. 5. Pressure drop through annular space with 5-in. OD 19.50 lb drill pipe in 8.83 in. ID casing (tool joints, 4½-in. IF; mud weight 10.3 lb per gal: mud viscosity not determined under conditions of flow).**

pressure drop per 1000 ft of 5-in. OD, IU drill pipe equipped with 4½-in. IF tool joints is approximately 40 per cent less than the pressure drop through 4½-in. EUIF drill pipe. The 5-in. OD drill pipe was field tested in several wells and satisfactory performance from the standpoint of all drilling requirements was obtained when used with the same sizes of holes (8⅝-in. and larger) that were drilled while using 4½-in. OD drill pipe. In addition to the decreased pressure drop, the 5-in. drill pipe offers 33 per cent greater torsional strength than 4½-in. drill pipe. Humble, therefore, decided to equip all their drilling rigs operating in drag bit territories with 5-in. OD drill pipe as the need for replacing 4½-in. drill pipe arose.

Another means of circulating a maximum volume of mud with available equipment is to enlarge bit nozzles. The pressure drop through bit nozzles was investigated, and it was found that two 1⅛-in. nozzles, as shown by theoretical data in Fig. 3, required a pressure of from 50 to 200 psi when used with circulating rates on the order of 400 to 700 gpm. The calculated pressure drops have been found in close agreement with the data obtained from field tests. Since a pressure drop through the bit of 50 to 200 psi was considered of minor order in the total pressure required in the circulating system, two 1⅛-in. nozzles for each two-way drag bit were adopted as standard in Humble's drag bit drilling operations.

The pressure drop through the standpipe, hose, swivel, kelly, and drill collars, as shown by test data in Fig. 4, was not considered great enough to alter the size of any of these pieces of equipment. The small magnitude of the return losses is shown by Fig. 5.

In addition to the means adopted for circulating the maximum volume of drilling fluid with available equipment, Humble conducted drilling tests in seven wells during the latter part of 1944 to determine further the relationship of circulating rate to drilling rate. The results obtained in five of these wells are shown in Table 1, and the results obtained in the remaining two are illustrated in Fig. 6. The tests shown in Table 1 were conducted by alternating single and compound pump operation between joints, whereas the test results shown in Fig. 6 were obtained by throttled operation

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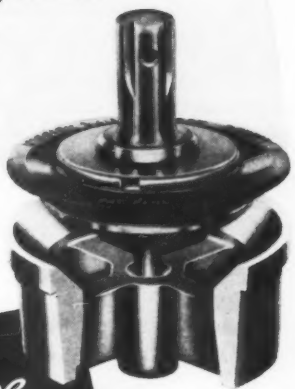

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**TABLE 1. Preliminary studies of effect of circulating rate on drilling with commercial drag type bits—*South Louisiana area***

| Lease and well number | Average circulating rate, gpm | | | Average drilling rate, ft per hr. | | |
|---|---|---|---|---|---|---|
| | Single pump | Compound | Per cent increase | Single pump | Compound | Per cent increase |
| Sarpy Brothers 1—1400 ft Predominantly sand | 483 | 596 | 23.4 | 20.6 | 21.7 | 5.3 |
| Petit Anse Co. Inc. B-3—639 ft Broken sand and shale | 508 | 567 | 10.6 | 22.1 | 24.1 | 9.0 |
| M. Wooster B-7—170 ft Sand and Shale | 395 | 437 | 10.6 | 9.1 | 9.0 | — 1.1 |
| So. Tex. Rice Prod. 2—1046 ft Sandy shale | 466 | 634 | 36.0 | 37.7 | 54.7 | 45.0 |
| State Land A-30—1027 ft Sand and shale | 454 | 517 | 13.8 | 24.0 | 21.6 | —10.0 |

of a single 20-in. duplex pump while drilling from 43 to 175 ft of hole at each rate of circulation in uniform formation. The data show that the drilling rate varied directly with the circulating rate. However, during the tests, little attention was given to nozzle fluid velocity or to bit weight, which were later to be recognized as very important factors.

● **Rate of drilling.** The promising results indicated by the preliminary work on hydraulics led to the initiation, early in 1946, of a Petroleum Engineering Research Project to conduct an intensive study of drag bit drilling technique directed toward the evaluation of all factors which affect rate of penetration.

*Circulating rate.* It was recognized that rate of circulation and bit weight were very important factors in drag bit drilling; that is, at higher rates of circulation a greater bit weight than had heretofore been considered good practice could be used without endangering the hole. In Fig. 7, the results of one of the first tests conducted to determine the interrelation of bit weight, circulating rate, and nozzle fluid velocity are shown. The section to be tested was located by means of an electric survey of an offset well as a uniform section of shale. The data show that a greater bit weight can be maintained effectively on the bit at a greater circulating rate. At a circulating rate of 290 gpm, the maximum possible drilling rate was 75 ft per hr, whereas at 631 gpm the maximum possible drilling rate was 400 ft per hr. The data also illustrate the importance of maintaining a bit weight just short of the balling up point, if full advantage is to be obtained of an increase in the volume of mud circulated. At 20,000 lb bit weight, penetration was great enough that complete balling up occurred at all circulating rates and nozzle fluid velocities employed.

Because the data shown in Fig. 7 was obtained with the use of only one bit, the nozzle fluid velocity necessarily varied directly with the circulating rate. Hence, the exact effect of either circulating rate or nozzle fluid velocity could not be determined, inasmuch as both factors were variable during the test. However, the overall results show that a 117 per cent increase in both circulating rate and nozzle fluid velocity resulted in a 433 per cent increase in drilling rate at a bit weight just short of the balling-up point. Furthermore, extremely low rates of circulation resulted in no drilling progress.

To isolate the effect of rate of circulation, a test was conducted in the Galveston Bay State A-39, Red Fish Reef field, Chambers County, Texas, to determine the effect of rate of circulation on rate of drilling at a constant nozzle fluid velocity. The test was conducted in a section of unifom shale near 8000 ft, which was located by means of an electric survey of an offset well. The drillers were instructed to maintain the maximum bit weight just short of balling up, and short intervals were drilled with three bits equipped with various sized nozzles. The results of the test are shown in Fig. 8, where the variation of circulating rate with constant nozzle fluid velocity and drilling rate is plotted. The number and size of nozzles for each two-way bit are shown on the figure.

The data in Fig. 8 show that as the circulating rate increased from 381 to 568 gpm, or 49 per cent, the drilling rate was increased from 65 to 97 ft per hr, or 49 per cent. The nozzle fluid velocity during the test only varied from 116 to 138 fps. Such a variation is believed to be too small to result in any appreciable effect on the drilling rate. The drilling rate in the well referred to above was, therefore, considered to vary directly with the circulating rate.

*Bit weight.* During the early studies of the hydraulics of rotary drilling, the results of some of the tests were difficult to interpret as a result of insufficient knowledge concerning bit weight. At the start of the research project established by Humble to study the hydraulics of rotary drilling, two 6000-ft wells were drilled in the Seeligson field, Kleberg County, Texas, with the rate of circulation varying by 24 per cent between wells. The drilling factors were left entirely to the drillers' judgment, and, as a result, interpretation of the data was difficult because of the large variation of bit weight used by different drillers. As would be expected, however, the fastest drilling rates were usually attained by the drillers who maintained a uniformly higher bit weight.

The effect of bit weight on drilling rate was investigated further during tests conducted from 4331 to 5030 ft in the King Ranch Cabeza 67 well, Seeligson field, where 6-ft intervals of uniform shale in each test were drilled at various bit weights while the circulating rate and nozzle fluid velocity were maintained constant at 820 gpm and 107 fps, re-

**FIG. 6. Variation of drilling rate of two-way drag type bits with rate of circulation at constant nozzle diameter (speed of rotation 85 to 110 rpm; bit weight, 6000 to 10,000 lb; bit nozzle sizes not recorded; mud properties constant but not recorded —South Texas area).**

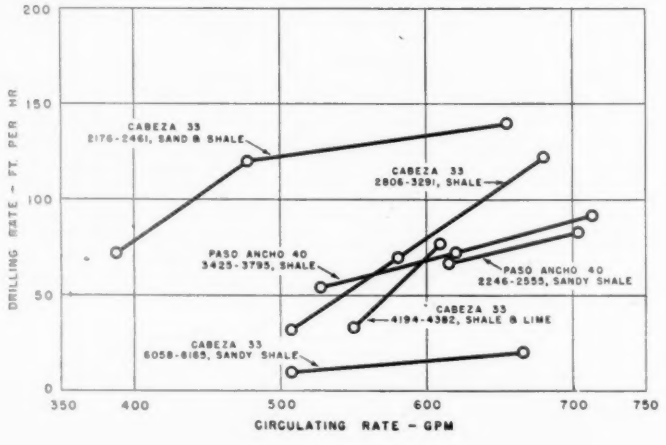
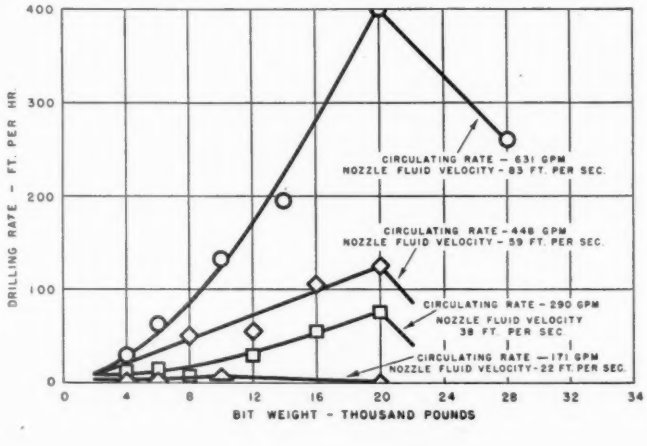



**FIG. 7. Combined effect of circulating rate, nozzle fluid velocity, and bit weight at constant speed of rotation on rate of drilling with two-way drag type bits (mud properties constant, uniform shale; King Ranch-Cabeza 68 well—3110 to 3212 ft. South Texas area).**


DRILLING RATE - FT. PER HR.
BIT WEIGHT - THOUSAND POUNDS
CIRCULATING RATE - 631 GPM
NOZZLE FLUID VELOCITY - 83 FT. PER SEC.
CIRCULATING RATE - 448 GPM
NOZZLE FLUID VELOCITY - 59 FT. PER SEC.
CIRCULATING RATE - 290 GPM
NOZZLE FLUID VELOCITY
38 FT. PER SEC.
CIRCULATING RATE - 171 GPM
NOZZLE FLUID VELOCITY - 22 FT. PER SEC.

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# LINK-BELT BALL AND ROLLER BEARINGS

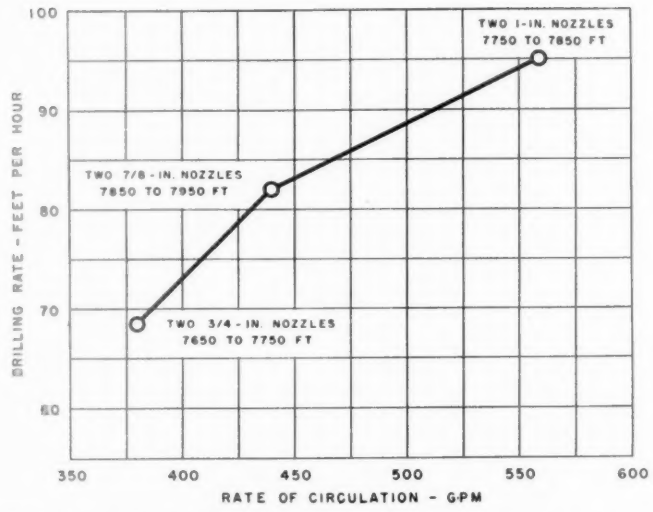



**FIG. 8. Variation of drilling rate of two-way drag type bits with rate of circulation at near constant nozzle fluid velocity, constant speed of rotation and maximum effective bit weight (nozzle fluid velocity, 116 to 138 ft per sec: Bit weight 8,000 to 10,000 lb; uniform shale formation; mud properties constant but not recorded; speed of rotation, 140 rpm—Gulf Coast, Texas area).**

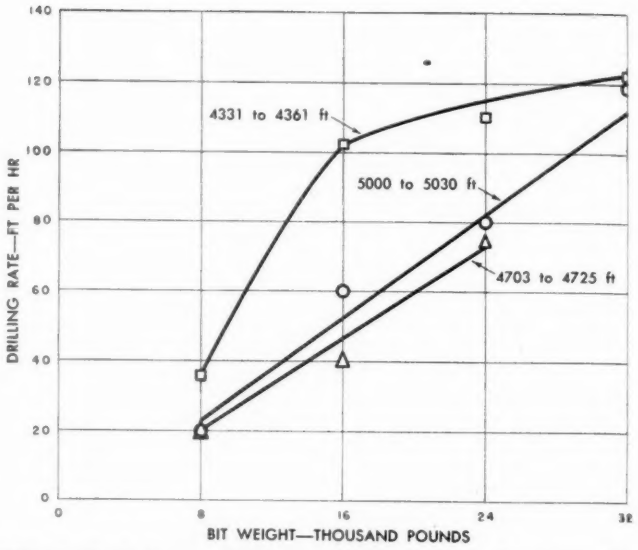



**FIG. 9. Variation of drilling rate of two-way drag type bits with bit weight at constant rate of circulation and speed of rotation (King Ranch-Cabeza 67 well—4331 to 5030 ft; uniform shale formation; mud properties constant but not recorded: Rate of circulation 820 gpm; nozzle fluid velocity, 107 ft per sec.—South Texas area).**

spectively. Indications during the tests were that the bit was clean at all bit weights; therefore, the factor of a balled up bit did not enter into the tests. The results of the tests illustrated graphically in Fig. 9 show that the drilling rate varies directly with bit weight. A maximum bit weight of 32,000 lb was used during the tests because of a limited number of drill collars in use. Had enough bit weight been applied to the bit, however, balling up would have occurred, and rate of drilling would have slowed or stopped. This effect is illustrated in Fig. 7 where the bit weight at each rate of circulation was increased until the bit was balled up. In addition to the balling up effect shown in Fig. 7, the effect of bit weight on rate of drilling is also shown.

*Nozzle fluid velocity.* To determine the effect of drag bit nozzle fluid velocity on the rate of drilling, a series of tests was conducted in the J. F. Grant 3 well in the Sugar Valley field, Matagorda County, Texas, the results of which are shown in Table 2. The trend of the results indicates that drilling rate can be increased with an increase in nozzle fluid velocity. These tests, however, were considerably affected by changes in formation between the relatively short intervals drilled.

Another series of tests was conducted in the Frank Schmidt 3 well, Danbury field, Brazoria County, Texas, the results of which are also shown in Table 2. Through interval 1 in the Frank Schmidt 3, a constant bit weight was maintained, but through interval 2, the maximum bit weight just short of balling up the bit was used. Through interval 1, even though the bits were spudded at any time deemed advisable, it is believed that the bits with the larger nozzles were unduly penalized because of balling up resulting from too great a bit weight. To

**TABLE 2. Effect of nozzle fluid velocity on rate of drag bit drilling at constant rate of circulation.**

*Gulf Coast Texas area*

| Bit no. | Number of nozzles per bit | Size nozzles, in., ID | Rate of circulation, gpm | Nozzle fluid velocity, fps | Feet drilled | Bit weight, lb | Drilling rate, ft per hr |
|---|---|---|---|---|---|---|---|
| | | | ***F. J. Grant 3*** | | | | |
| | | | Interval 1—4312 to 5050 ft | | | | |
| 1 | 2 | 5/8 | 700 | 365 | 138 | 8,000 | 151 |
| 4 | 2 | 5/8 | 700 | 365 | 150 | 8,000 | 204 |
| 3 | 2 | 1 | 700 | 142 | 150 | 8,000 | 72 |
| 2 | 2 | 13/16 | 700 | 75 | 150 | 8,000 | 82 |
| 5 | 2 | 13/16 | 700 | 75 | 150 | 8,000 | 63 |
| | | | Interval 2—6200 to 6600 ft | | | | |
| 9 | 2 | 5/8 | 630 | 328 | 100 | 8,000 | 94 |
| 7 | 2 | 1 | 630 | 129 | 100 | 8,000 | 53 |
| 8 | 2 | 21/32 | 630 | 30 | 100 | 8,000 | 28 |
| 9 | 2 | 5/8 | 630 | 328 | 50 | 14,000 | 71 |
| 7 | 2 | 1 | 630 | 129 | 50 | 14,000 | 88 |
| | | | Interval 3—6607 to 7050 ft | | | | |
| 12 | 2 | 5/8 | 630 | 328 | 53 | 4,000 | 66 |
| 10 | 2 | 1 | 630 | 129 | 68 | 4,000 | 78 |
| 11 | 2 | 13/16 | 630 | 68 | 75 | 4,000 | 56 |
| 12 | 2 | 5/8 | 630 | 328 | 75 | 8,000 | 64 |
| 10 | 2 | 1 | 630 | 129 | 75 | 8,000 | 66 |
| 11 | 2 | 13/16 | 630 | 68 | 75 | 8,000 | 51 |
| | | | ***Frank Schmidt 3*** | | | | |
| | | | Interval 1—5000 to 5293 ft | | | | |
| 1 | 2 | 5/8 | 628 | 327 | 100 | 10,000 | 193 |
| 3 | 4 | 1/2 | 628 | 256 | 100 | 10,000 | 80 |
| 5 | 2 | 1 | 628 | 128 | 27 | 10,000 | 33 |
| 4 | 4 | 3/4 | 628 | 113 | 38 | 10,000 | 22 |
| 2 | 2 | 13/16 | 628 | 67 | 63 | 10,000 | 20 |
| | | | Interval 2—5366 to 5866 ft | | | | |
| 6 | 2 | 5/8 | 570 | 296 | 100 | 4,000 to 6,000 | 182 |
| 8 | 4 | 1/2 | 570 | 232 | 100 | 4,000 to 10,000 | 122 |
| 10 | 2 | 1 | 570 | 115 | 100 | 4,000 to 6,000 | 87 |
| 7 | 4 | 3/4 | 570 | 103 | 100 | 4,000 to 10,000 | 47 |
| 9 | 2 | 13/16 | 570 | 61 | 100 | 2,000 to 4,000 | 46 |

prevent this through interval 2, the maximum bit weight just short of balling up was maintained. It is believed, therefore, that the results obtained through interval 2 in the Frank Schmidt 3 well, Danbury field, are more indicative of the true relationship of nozzle fluid velocity to rate of drilling with drag type bits. Data from the Frank Schmidt 3 well on drilling rate versus nozzle fluid velocity are plotted in Fig. 10. The results indicate that the rate of drilling that can be obtained with drag type bits in the type of shale encountered in the Schmidt 3 is in direct proportion to the nozzle fluid velocity when the rate of circulation is constant and a maximum effective bit weight is maintained.

To evaluate the relation of nozzle fluid velocity to drilling rate on a per well basis, the 8⅝-in. hole in three wells in the Borregas field, Kleberg County, Southwest Texas, was drilled with two-way bits equipped with 1⅛-in. ID bit nozzles for one well and ⅝-in. ID bit nozzles for two wells, while the rate of circulation was maintained approximately constant between wells. Maximum effective bit weights not exceeding 40,000 lb were employed for all three wells and rotary speeds ranged from 100 to 175 rpm for each of the three wells. The drilling data accumulated during these tests are summarized in Table 3. Two wells were also drilled in the Sugar Valley field, Matagorda County, Texas, where two-way bits equipped with two 1⅛-in. ID nozzles were used in one well and two-way bits equipped with two ½-in. nozzles were used in the other well. The comparable drilling data in the two Sugar Valley wells are shown in Table 4.

**TABLE 3. Effect of nozzle fluid velocity and hydraulic horsepower on rate of drilling—** *Borregas field, South Texas area*

| Lease and well no. | Borregas 19 | Borregas 42 | Borregas 16 |
|---|---|---|---|
| Depth, ft From | 2,049 | 2,064 | 2,050 |
| To | 6,895 | 6,875 | 6,872 |
| Hole drilled, ft | 4,362 | 4,429 | 4,467 |
| Rotating hours | 151.78 | 79.43 | 39.20 |
| Drilling rate, ft/hr | 28.7 | 59.1 | 114.0 |
| Average circulating rate, gpm | 550 | 487 | 700 |
| Number of nozzles and diameter | Two 1⅛-in. ID | Two ⅝-in. ID | Two ⅝-in. ID |
| Bit nozzle fluid velocity, ft/sec | 90 | 255 | 375 |
| Total hydraulic horsepower | 200 | 313 | 800 |
| Average bit weight, lb | 15,000 | 20,000 | 30,000 |
| Maximum hole deviation, deg | 2½ | 2½ | 3¼ |

A comparison of the Borregas wells shows that the drilling rate varied with the nozzle fluid velocity used in the wells. In the Sugar Valley wells, it is seen that a 34 per cent decrease in circulating rate and a 228 per cent increase in nozzle fluid velocity resulted in 101 per cent increase in drilling rate in the Truitt and Gravier 2 when compared with the A. B. Taylor 2, while the hydraulic horsepower developed in the two wells was approximately equal.

*Hydraulic horsepower.* The data obtained by Humble concerning drilling with commercial drag type bits indicate that two hydraulic relationships exist, namely: (1) The rate of drilling is directly proportional to the nozzle fluid velocity when the rate of circulation is constant, and (2) the rate of drilling is directly proportional to the circulating rate when the nozzle fluid velocity is constant.

In Fig. 11, the variation of relative drilling rate with hydraulic horsepower at (1) variable circulating rate and constant nozzle fluid velocity and (2) variable nozzle fluid velocity and constant circulating rate are shown for 8⅝-in. two-way bits, 4½-in. 16.60-lb EUIF drill

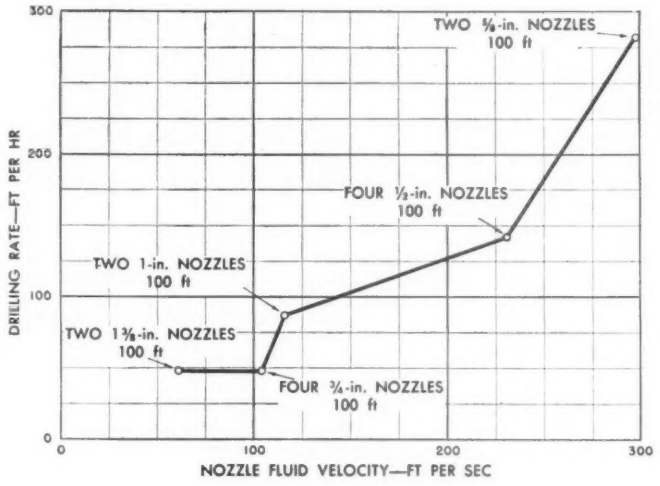
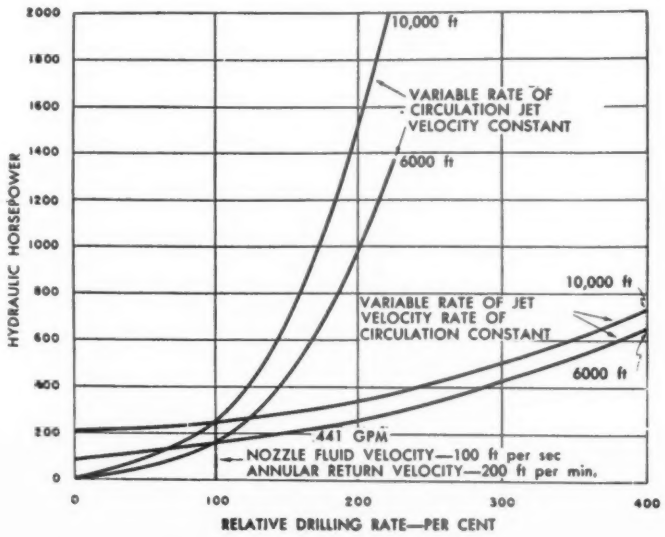



**FIG. 10. Left—Variation of drilling rate of two-way drag type bits with nozzle fluid velocity at constant rate of circulation, constant rotary speed, and maximum effective bit weight (rate of circulation 570 gpm; speed of rotation, 140 rpm; bit weight, 2000 to 10,000 lb; data obtained from Frank Schmidt 3 well—5366 to 5866 ft; formation, uniform shale—Texas Gulf Coast.)**

**FIG. 11. Left below—Calculated relation of hydraulic horsepower with drilling rate at constant speed of rotation and maximum effective bit weight (drill pipe, 4½-in. 16.60 lb EUIF, mud weight 10.0 to 10.3 lb per gal; mud viscosity not determined under conditions of flow).**

**FIG. 12. Below—Calculated relation of hydraulic horsepower with drilling at constant speed of rotation and maximum effective bit weight (drill pipe 5-in. OD 19.50 lb equipped with 4½-in. IF tool joints; mud weight 10.0 to 10.3 lb per gal; mud viscosity not determined under conditions of flow).**



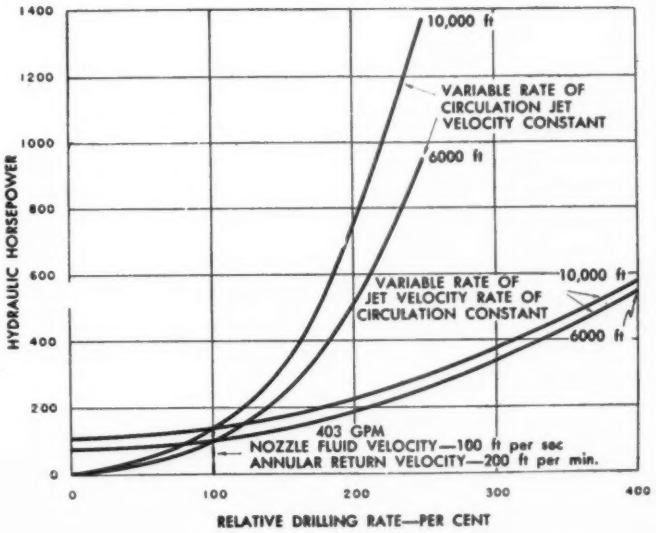



**TABLE 4. Effect of nozzle fluid velocity and hydraulic horsepower on rate of drilling.**

*Sugar Valley field, Gulf Coast, Texas*

| Lease and well no. | A. B. Taylor 2 | Truitt and Gravier 2 |
|---|---|---|
| Depth, ft From | 3,050 | 3,050 |
| To | 8,030 | 8,168 |
| Hole drilled, ft | 4,980 | 5,118 |
| Number of bits used | 7 | 4 |
| Rotating hours | 102.30 | 52.30 |
| Drilling rate, ft/hr | 48.68 | 97.86 |
| Average circulating rate, gpm | 736 | 479 |
| No. and diameter of nozzles | Two 1⅛-in. | Two ½-in. |
| Bit nozzle fluid velocity, ft/sec | 119 | 391 |
| Total hydraulic horsepower | 403 | 419 |
| Average bit weight, lb | 9,000 | 25,000 |
| Maximum hole deviation, deg | 3¼ | 4½ |

pipe and approximately 10.0-lb-per-gal mud at depths of 6000 and 10,000 ft. Fig. 12 shows the same information with the exception that 5-in. OD drill pipe is used in the calculations in place of the 4½-in. EUIF drill pipe. Data from Figs. 2, 3, 4, and 5 were used to obtain the pressure losses through the various parts of the circulating system from which hydraulic horsepower calculations were made for Figs. 11 and 12. A relative drilling rate of 100 per cent was assumed to be the drilling rate that could be obtained at a nozzle fluid velocity of 100 fps and an annular return velocity of 200 fpm. It is seen by observation of the curves in Figs. 11 and 12 that any increase in drilling rate above the 100 per cent points can best be obtained by an increase in nozzle fluid velocity, rather than an increase in circulating rate for the depths illustrated. For greater depths, the horsepower advantage of increased nozzle fluid velocity over increased rate of circulation as a means of increasing drilling rate becomes rapidly larger. At shallower depths, the horsepower advantages to be gained by the nozzle fluid velocity method gradually decrease, but are never entirely eliminated. Thus, the fastest rate of drag bit drilling with any particular rig can be obtained when most of the horsepower available for mud circulation above that amount required to supply a safe annular return velocity is utilized to increase the bit nozzle fluid velocity.

*High nozzle fluid velocity.* An attempt to drill a complete 8⅝-in. hole in a Sugar Valley field well with a nozzle fluid velocity near 300 fps while using two-way standard curved bladed bits equipped with alloy steel nozzles directed to the blades was not successful because of excessive fluid erosion of the nozzles, as illustrated in Fig. 13. A switch to tungsten carbide nozzles resulted in erosion of the bit blades as shown in Fig. 14. Tungsten carbide nozzles directed ahead of blades were therefore adopted in order to eliminate all erosion; straight blades were substituted for curved blades in order that the nozzles could be directed as far ahead of the blades as possible in the limited space available.

A study of the effect of blade angle and nozzle direction on the rate of drilling was conducted in the Truitt and Gravier 1 well, Sugar Valley field, Matagorda County, Texas, where 75-ft intervals of uniform shale, as located by an electric log of an offset well, were drilled with bits equipped with nozzles directed to various points in front of standard curved blades and straight blades. The nozzles were directed to the same location on the bottom of the hole, approximately 1 in. from the wall, regardless of how far in front of the blade they were directed. The results of the tests conducted in the Truitt and Gravier 1, as shown in Table 5, indicate that, from the standpoint of drilling rate, the straight bladed bit with nozzles directed ahead of the blades is as good as or better than, the standard curved bladed bit equipped with nozzles directed to the blades.

**FIG. 13. Example of excessive fluid erosion of bit nozzle.**

**FIG. 14. Example of excessive fluid erosion of bit blade.**

It had not been determined, however, whether straight bladed bits equipped with nozzles directed ahead of the blades would perform satisfactorily at low nozzle fluid velocities near 100 fps. To determine this, a portion of the 8⅝-in. hole was drilled with bits equipped with nozzles directed 1½ in. ahead of straight blades in the King Ranch Borregas 33 well, Borregas field, Kleberg County, Texas, at an average nozzle fluid velocity of 90 fps. When the drilling with the straight bladed bits is compared in Table 6 with the drilling of the standard curved bladed bits in the King Ranch Borregas 19 well 6500 ft away, where equal circulating rates, nozzle sizes, and drilling techniques were used, the straight bladed bits with nozzles directed ahead of the blades performed better than the standard bits.

As an aid in finding the most advantageous direction for drag bit nozzles, chip formation studies were conducted in clays of various hardness and in paraffin. Typical chips are shown in Figs. 15 and 16 for clay and in Fig. 17 for paraffin. It is noted that the chips are similar in nature and tend to curve upward and away from the blade. The chip studies, Fig. 16, show further that nozzle fluid directed ahead of the blades should break or disintegrate the chip better than

**TABLE 5. Effect of nozzle direction and blade curvature on drilling rate.**

*Truitt and Gravier I, Matagorda County, Texas (Gulf Coast)*

| Bit no. | Direction nozzles with respect to blades | Blades | Depth From | Depth To | Feet drilled | Drilling time, min. | Circulating rate, gpm | Circulating pressure, psi | Nozzle fluid velocity | Hydraulic horsepower | Drilling rate, ft/hr |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Tangent and parallel | Straight | 6,175 | 6,250 | 75 | 56.0 | 608 | 1700 | 318 | 605 | 80 |
| 2 | 1½-in. in front | Straight | 6,250 | 6,325 | 75 | 19.9 | 592 | 1700 | 309 | 588 | 226 |
| 3 | ⅜-in. in front and parallel | Straight | 6,325 | 6,400 | 75 | 18.2 | 592 | 1700 | 309 | 588 | 247 |
| 4 | 2½-in. in front | Straight | 6,400 | 6,475 | 75 | 22.1 | 592 | 1750 | 309 | 605 | 204 |
| 5 | ⅜-in. in front and parallel | Straight | 6,475 | 6,550 | 75 | 28.4 | 592 | 1750 | 309 | 605 | 158 |
| 6 | 1½-in. in front | Straight | 6,550 | 6,625 | 75 | 16.6 | 592 | 1775 | 309 | 613 | 271 |
| 7 | Tangent and parallel | Straight | 6,625 | 6,700 | 75 | 14.1 | 592 | 1700 | 309 | 588 | 319 |
| 8 | Standard | Curved | 6,700 | 6,775 | 75 | 27.7 | 578 | 1700 | 302 | 574 | 162 |

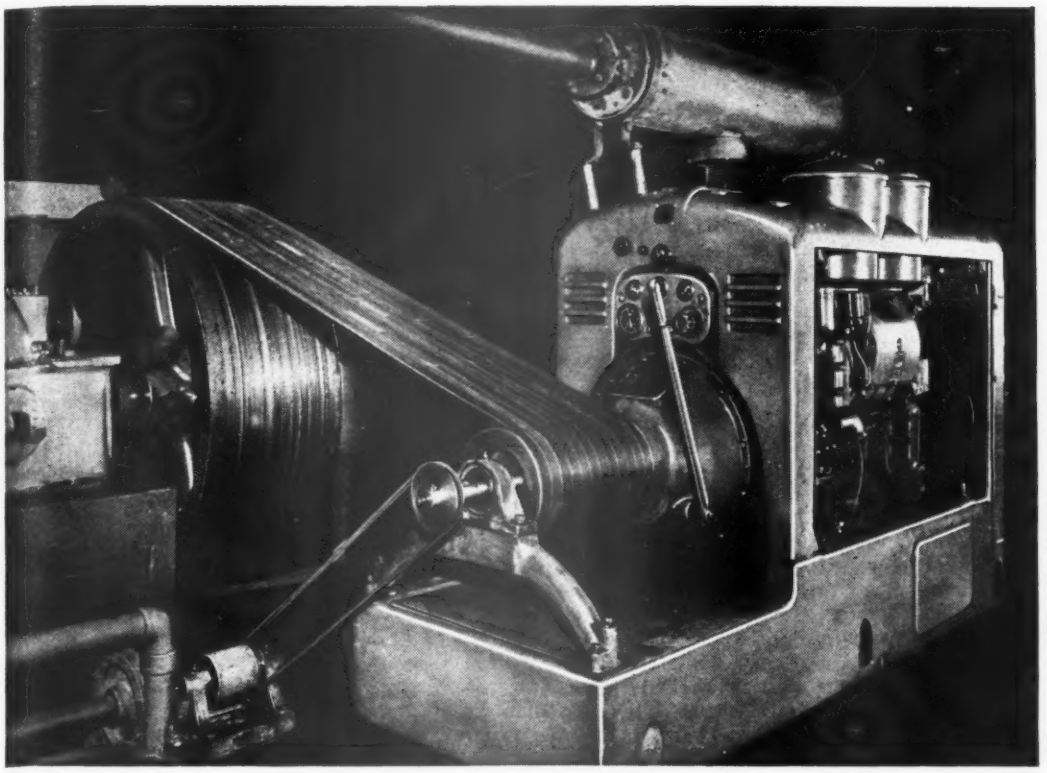


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**TABLE 6. Effect of nozzle direction and blade curvature on drilling rate.**
*Average circulating rate—590 gpm. Average nozzle fluid velocity—90 fps*
*Kleberg County, Southwest Texas area*

| Well and no. | Bit | | From | To | Hole drilled, ft | Net rotating time, hr | Drilling rate, ft/hr |
|---|---|---|---|---|---|---|---|
| | No. | Type | | | | | |
| Borregas 19 | 1 & 2 | Standard 2-Way* | 2049 | 4825 | 2776 | 45.23 | 61.37 |
| Borregas 33 | 1 | Special 2-Way† | 2050 | 4836 | 2786 | 40.13 | 69.42 |
| Borregas 19 | 3 | Standard 2-Way | 4902 | 5230 | 328 | 15.50 | 21.16 |
| Borregas 33 | 1 | Special 2-Way | 4897 | 5235 | 338 | 5.98 | 56.52 |
| Borregas 19 | 4 & 5 | Standard 2-Way | 5345 | 5798 | 453 | 20.94 | 21.63 |
| Borregas 33 | 2 | Special 2-Way | 5323 | 5788 | 354‡ | 15.45 | 22.91 |

*Curved blades with nozzles directed to blades.
†Straight blades with nozzles directed 1½-in. in front of blades.
‡Because of two drill pipe washouts, 111 ft of hole and 4.85 hr. were omitted from interval.

nozzle fluid that is directed toward the blade. Bits equipped with nozzles directed 1½ in. ahead of straight blades were used on all of the high nozzle fluid velocity tests illustrated by Tables 3 and 4.

The drilling tests summarized in this paper indicate that washing out the hole ahead of the bit was of minor importance and that the bit blades were responsible for the drilling of the formation, except in very soft formation near the surface. In the soft formations near the surface where no weight could be detected on the weight indicator during the drilling, the formation was found to wash out ahead of the bit as much as 3 ft in 30 sec. In formations that required weight to drill, however, no washing out ahead of the bit could be detected. It is, therefore, believed that the major function of the nozzle fluid is the disintegration of the chips that are formed by the bit blades.

*Annular return velocity.* The annular return velocity needed for drilling depends on several factors including the rate of drilling, mud viscosity, and sloughing tendency of the hole. Formulas for the slip velocity of particles were presented by Pigott.[4] The turbulent or maximum slip velocity in water of a round flat particle 0.5 in. in diam, according to Pigott, is 0.90 fps, or 54 fpm. Inasmuch as drill cuttings are predominantly flat and are usually less than 0.5 in. in diam, and drilling mud with a greater lifting capacity than water is normally in use, it is believed than an annular return velocity at some value greater than 54 fpm should be satisfactory for most drag bit drilling. In Humble's drag bit drilling operations, an annular return velocity based on a theorectical value of 200 fpm has been used with success. It is believed that the upper limit of usable return velocity is the point at which turbulent flow occurs in the annular space. Any increase in circulating rate above the turbulent flow point would increase the problem of lost returns because of the rapid increase in pressure on the formation.

*Drilling mud.* Many articles appear in the published literature on the importance of drilling mud control in rotary drilling. Most of the work that has been done on drilling mud is concerned with the relationship of mud properties to problems such as blowouts, lost returns, heaving shale, and filter cake formation.

It has been reported that drilling mud in any form retards the rate of penetration obtainable with rock bits in the hard formations encountered in the Permian basin of Texas and New Mexico.[5, 6] Observations have indicated that the same is true for certain types of drag bit drilling under specified operating conditions. However, no data are available concerning tests that have been conducted to determine the effect of variation in the properties of water-base mud on the rate of drilling with drag bits. Special muds, such as silicate-base and oil-base muds, have been observed to accelerate the rate of drilling in certain shale formations.

Mud viscosities as measured by the conventional methods, i.e., with a Stormer viscosimeter or Marsh funnel, vary over wide limits. However, these viscosity differences largely disappear at the turbulent rate of flow obtained in the drill pipe and bit nozzles. Fig. 8 shows the effect of rate of shear as obtained with a Stormer viscosimeter on the viscosity of two different samples of drilling mud. It is noted that the mud weighing 10.1 lb per gal attained a minimum viscosity of approximately 6 centipoise at 300 rpm, and the mud weighing 16.4 lb per gal attained a minimum viscosity of approximately 27 centipoise at 350 rpm on the Stormer viscosimeter. If these viscosity values are substituted in the equation for determining pressure loss in pipe at various rates of flow, values are obtained far in excess of actual measured values. This leads to the conclusion that the effect of agitation on mud viscosity as it is circulated through 4-½-in. OD or 5-

**FIG. 15. Generation of drag type bit chip in clay formation at drilling rate comparable to 250 fph at 150 rpm.**

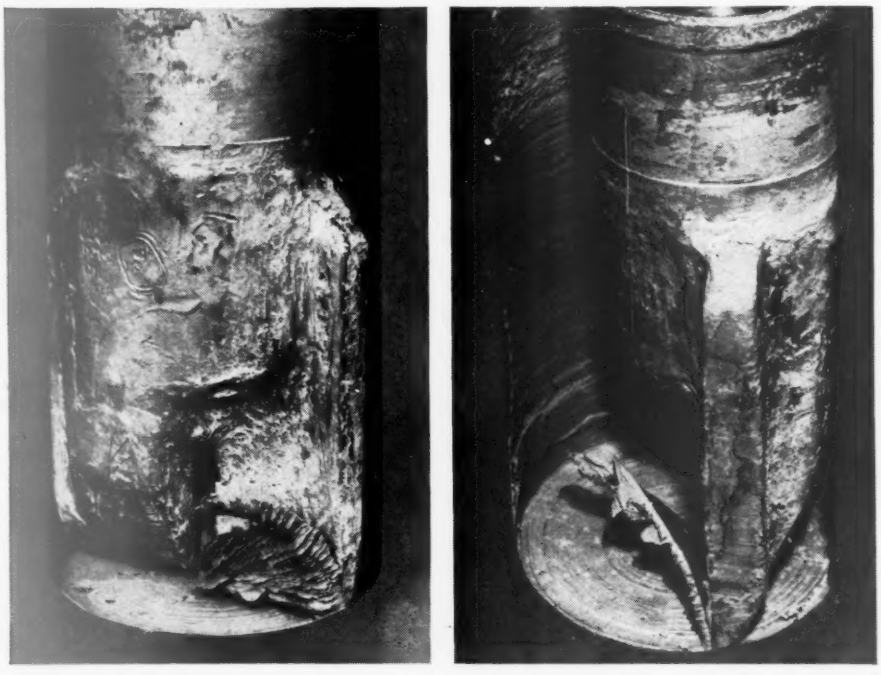

**FIG. 16. Relation of fluid nozzle discharge to chip generated by drag type bit modified for high nozzle fluid velocity drilling.**

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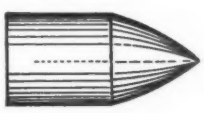

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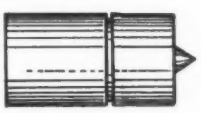
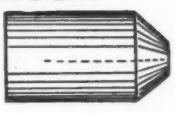
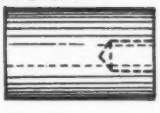


SEMI-MUSHROOM



FULL MUSHROOM



NEEDLE

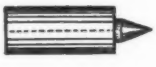


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**FIG. 17. Generation of drag type bit chip in paraffin at drilling rate comparable to 250 ft per hr, 150 rpm.**

in. OD drill pipe is greater than the maximum obtained with a Stormer viscosimeter.

As the measurable viscosity differences in drilling muds largely disappear under conditions of use in the drill pipe, it is felt that mud viscosity contributes a negligible amount to the drilling rate obtained with drag bits. This is assuming that a rate of mud circulation sufficiently high to produce turbulent flow in the drill pipe is employed.

It is frequently stated that the rate of drilling with drag type bits is retarded at extremely high mud weights. When drilling in abnormally high pressure formation areas, precautions that slow down the drilling rate are usually employed. Also, as the pressure drop in the circulating system is proportional to the mud density, the change from a normal to a high weight mud results in a reduction in the mud volume circulated, unless provisions are made to increase the circulating capacity of the mud pumps. This reduction in mud circulating rate, and not necessarily the change in the mud weight, can contribute considerably to the reduced drilling rate.

It has been reported that the rate of drilling can be affected by the chemical constituents of the drilling fluid; [7,8,9] however, there are no data available concerning work which has been carried out on this particular phase of the problem.

*Hole deviation.* To gain full advantage of either increasing circulating rate or bit nozzle fluid velocity, it has been shown that the bit weight must also be increased. To overcome the possibility of deviated holes, Humble used 270 ft of 6-¾-in. OD x 2-13/16-in. ID drill collars having a total weight of 27,000 lb during the tests shown in Tables 3 and 4. The tests show a slight trend toward greater deviation with increased bit weights, but the deviation of the wells was within acceptable limits and does not vary appreciably from the average deviation for other wells that have been drilled using a smaller amount of bit weight.

*Rotary speed.* The drilling tests that are summarized in this paper were conducted at rotary speeds that are normally accepted as good practice by drillers. The rotary speeds varied between 100 and 175 rpm, with the greater speeds being used with the faster rates of drilling. It is known that there is a definite relationship between speed of rotation and rate of drilling with drag type bits; furthermore, it is realized that vibration of the drillstem and heating of the bit when higher speeds of rotation are used limit the maximum rotary speed that may be employed. Tests are now in progress to establish a more exact relationship of rotary speed with rate of drilling and to determine practical upper limits of speed for drag bit drilling.

Another factor that will influence the rate of drilling and bit life as well is the number of blades on a single bit, for a greater number of blades offers a greater wearing surface. The effect of the number of bit blades on the rate of drilling at the higher nozzle fluid velocities is now being investigated by Humble. The number of bit blades that may be used along with Humble's adaptation of increased nozzle fluid velocities is limited, however, due to the nozzle being directed 1-½-in. ahead of the blade.

● **Application.** To apply the results of drag bit drilling research to actual drilling practices, Humble has adopted the following program on a number of company drilling rigs engaged in drag bit drilling:

1. As near as practical, most of the available horsepower for mud circulation above the amount required to supply a safe annular return is applied to increasing the bit nozzle fluid velocity.

2. Straight bladed bits equipped with a single tungsten carbide nozzle directed 1-½ in. ahead of each blade are used for all two-bladed bit requirements in 12-¼-in., 9-⅞-in., and 8-⅝-in. hole. The nozzles are round and vary in ID by the ⅛-in. from ½ to 1-⅛ in.

3. Unless justified by unusual hole conditions, the annular return velocity is maintained as close as practical to a theoretical value of 200 fpm with a minimum of 175 fpm.

4. Pump liners are used that will provide the required annular return velocity at 50 spm, except where the minimum sized nozzles are used and the pump or pumps will operate in excess of 55 spm. In such instances, larger liners are installed. A minimum sized liner of 6-½ in. ID is recommended for pumps in the 18- and 20-in. stroke sizes.

5. The maximum bit weight possible so as not to cause a deviated hole or ball up the bit is used.

In the application of such a program, primary attention is given to the hole size requiring the major portion of the drilling time. For instance, in most field drilling, surface pipe is set at depths varying from 1000 to 4000 ft, after which the hole for the production string is drilled to the total depth of the well. Inasmuch as the major portion of the drilling time will be consumed in drilling the production string hole, the most suitable sized pump liners are installed for this drilling; i.e., pump liners which will provide a theoretical annular return velocity of 200 fpm at a pump speed of 50 spm. In the larger, surface hole, the pumps are operated in parallel, and bit nozzles are installed which will al-

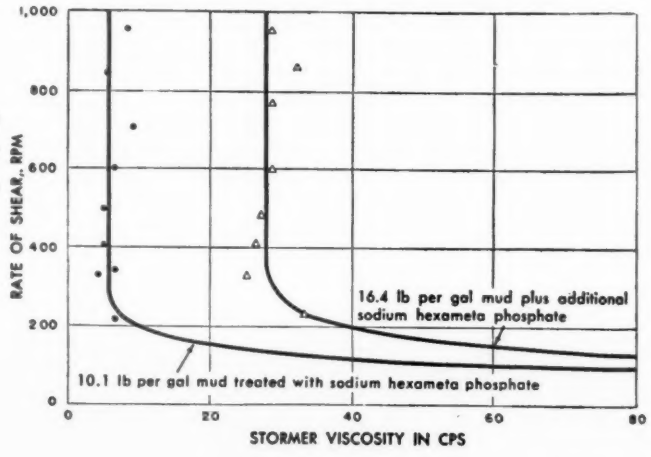


**FIG. 18. Rate of shear vs. sormer viscosity (natural shale mud).**

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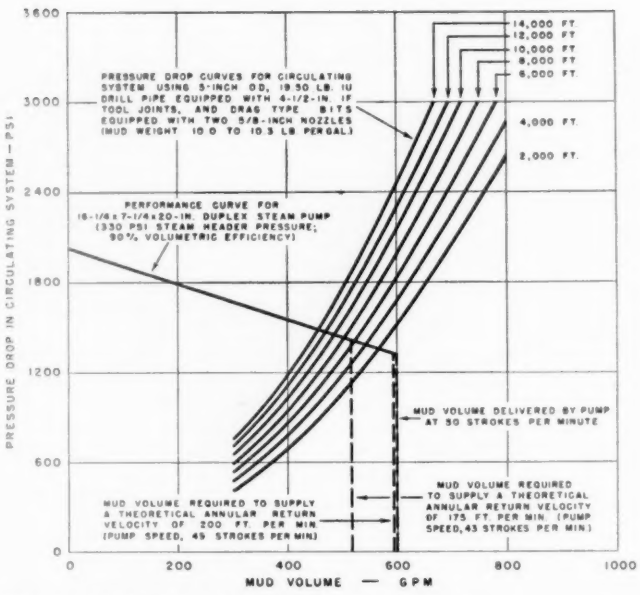
PRESSURE DROP CURVES FOR CIRCULATING SYSTEM USING 5-INCH OD, 19.50 LB. IU DRILL PIPE EQUIPPED WITH 4-1/2-IN. IF TOOL JOINTS, AND DRAG TYPE BITS EQUIPPED WITH TWO 5/8-INCH NOZZLES (MUD WEIGHT 10.0 TO 10.3 LB PER GAL.)
PERFORMANCE CURVE FOR 16-1/4 x 7-1/4 x 20-IN. DUPLEX STEAM PUMP (330 PSI STEAM HEADER PRESSURE; 90% VOLUMETRIC EFFICIENCY)
14,000 FT.
12,000 FT.
10,000 FT.
8,000 FT.
6,000 FT.
4,000 FT.
2,000 FT.
MUD VOLUME DELIVERED BY PUMP AT 50 STROKES PER MINUTE
MUD VOLUME REQUIRED TO SUPPLY A THEORETICAL ANNULAR RETURN VELOCITY OF 200 FT. PER MIN (PUMP SPEED, 49 STROKES PER MIN)
MUD VOLUME REQUIRED TO SUPPLY A THEORETICAL ANNULAR RETURN VELOCITY OF 175 FT. PER MIN. (PUMP SPEED, 43 STROKES PER MIN.)
PRESSURE DROP IN CIRCULATING SYSTEM — PSI
MUD VOLUME — GPM
3600
3000
2400
1800
1200
600
0
200
400
600
800
1000

**FIG. 19. Method for determining size of nozzles to use in 9⅞-in. two-way drag type bits.**

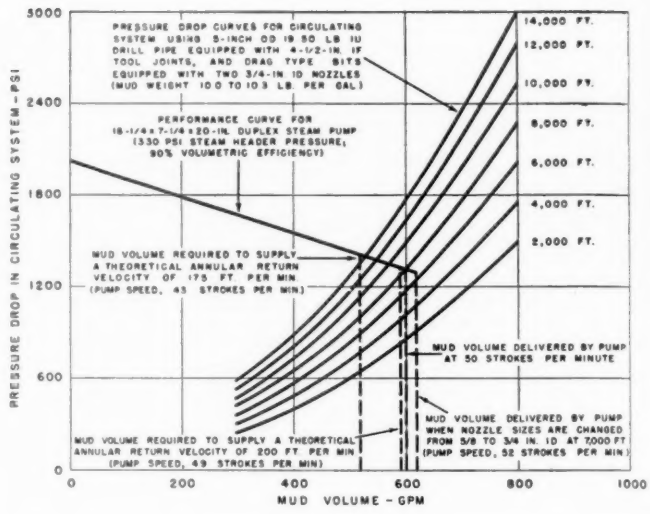
PRESSURE DROP CURVES FOR CIRCULATING SYSTEM USING 5-INCH OD 19.50 LB IU DRILL PIPE EQUIPPED WITH 4-1/2-IN. IF TOOL JOINTS, AND DRAG TYPE BITS EQUIPPED WITH TWO 3/4-IN ID NOZZLES (MUD WEIGHT 10.0 TO 10.3 LB. PER GAL.)
PERFORMANCE CURVE FOR 16-1/4 x 7-1/4 x 20-IN. DUPLEX STEAM PUMP (330 PSI STEAM HEADER PRESSURE; 90% VOLUMETRIC EFFICIENCY)
14,000 FT.
12,000 FT.
10,000 FT.
8,000 FT.
6,000 FT.
4,000 FT.
2,000 FT.
MUD VOLUME REQUIRED TO SUPPLY A THEORETICAL ANNULAR RETURN VELOCITY OF 175 FT. PER MIN (PUMP SPEED, 43 STROKES PER MIN)
MUD VOLUME DELIVERED BY PUMP AT 50 STROKES PER MINUTE
MUD VOLUME DELIVERED BY PUMP WHEN NOZZLE SIZES ARE CHANGED FROM 5/8 TO 3/4 IN. ID AT 7000 FT (PUMP SPEED, 52 STROKES PER MIN.)
MUD VOLUME REQUIRED TO SUPPLY A THEORETICAL ANNULAR RETURN VELOCITY OF 200 FT. PER MIN (PUMP SPEED, 49 STROKES PER MIN.)
PRESSURE DROP IN CIRCULATING SYSTEM — PSI
MUD VOLUME — GPM
3000
2400
1800
1200
600
0
200
400
600
800
1000

**FIG. 20. Method for determining size of nozzles to use in 9⅞-in. two-way drag type bits.**

low the pumps to operate at 50 spm each in order to approach the desirable annular return velocity.

Prior to the application of the recommended drilling practices, close estimates may be made of the nozzle sizes that will be required in the drilling of a well with any particular rig. An example is given as follows: A well is to be drilled to 10,000 ft with a rig equipped with an 18-in. diam steam end, 20-in. stroke mud pump, 5-in. OD drill pipe (4-½ IF tool joints), and 350-psi boilers. Surface hole will be drilled to 3000 ft, below which 9-⅞-in. production string hole will be drilled to a total depth of 10,000 ft. The size of the rig is such that only one pump operation can be maintained on the production string hole.

Solution: The major portion of the drilling will be 9-⅞-in. hole; therefore, pump liner sizes will be installed so as to provide at 50 spm a theoretical annular return velocity of 200 fpm in the 9-⅞-in. hole. Volume calculations show that 592 gpm will supply the desired annular return velocity. The volume per stroke required for the pump would be 592 divided by 50, or 11.84 gal. At 90 per cent volumetric efficiency and 2-¾-in. rods, the nearest sized pump liner available would be 7-¼-in. ID, which would deliver 11.94 gal per stroke.

The determination of the size of nozzles to use in the 9⅞-in. hole is illustrated in Figs. 19 and 20. In Fig. 19, the performance curve of the 18-in. x 7¼-in. x 20-in. steam pump is plotted in conjunction with the pressure drop in the circulating system of the rig when two ⅝-in. nozzles are in use, and in Fig. 20 the performance curve of the same pump is plotted in conjunction with the pressure drop in the circulating system when two ¾-in. nozzles are in use. The performance curve of the pump was determined by drawing a straight line between the stall pressure of the pump based on a steam header pressure of 330 psi (20 psi lower than boiler pressure to allow for steam line pressure drop) and the operating pressure at 50 spm based on 65 per cent stall pressure and 90 per cent volumetric efficiency. In Fig. 19, it can be seen that the ⅝-in. nozzles can be used to an approximate depth of 7000 ft, at which depth the annular return velocity will have decreased to the minimum recommended rate of 175 fpm. Below 7000 ft, two ¾-in. nozzles should be used since this is the next larger sized nozzle that is used in Humble's drilling program. In Fig. 19, it can be seen that the ¾-in. nozzle could be used satisfactorily to the total depth of the 10,000-ft well and even at depths in excess of 14,000 ft.

Should the size of the rig be such that two 18 in. × 7¼ in. × 20-in. pumps are operated in series, the operating pressure of the two pumps would be twice the amount shown in Fig. 19 and 20. Thus, smaller sized nozzles could be used through the same depth of hole intervals when compared with a single pump operation.

● **Conclusions.** Within the limits of this investigation where two-bladed drag type bits were rotated at speeds of from 100 to 175 rpm in drilling 8⅝-in. to 12¼-in. holes in the Texas-Louisiana Gulf Coast areas at maximum efficient bit weights up to 40,000 lb:

1. Drilling rate is directly proportional to nozzle fluid velocity.

2. Drilling rate is directly proportional to circulating rate.

3. The maximum rate of drilling with 2-way drag bits is obtained when the maximum weight just short of balling up is applied to the bit; at bit weights below the balling up point, rate of drilling is proportional to bit weight at constant speed of rotation.

4. The maximum rate of drilling with any rig can be obtained when all horsepower available for mud circulation is utilized in such a manner that a maximum value of the product of rate of circulation and bit nozzle fluid velocity is obtained. The rate of circulation so determined may be used in practice only when it is equal to or greater than the minimum rate required to produce a safe annular return velocity.

5. The use of drag type bits having more than two blades, the use of rotation speeds greater than 175 rpm and the economics of extreme nozzle fluid velocity drilling are worthy of investigation. The usefulness of much of the data presented in chart form may be extended when reduced to generalized equations.

● **Acknowledgment.** The authors sincerely appreciate the help and fine cooperation on the part of members of the Petroleum Engineering Division who assisted in gathering data, and particularly on the part of the district and drilling rig personnel concerned with running the many special tests required. Several manufacturers gave invaluable assistance in producing bits of special designs on short notice and in providing facilities for carrying out the studies on the cutting action of bit blades. Appreciation is also extended to the management of Humble Oil and Refining Company for permission to publish this paper.

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# Plastic pipe line coating and yard processing

By B. M. LAULHERE, JR.*

**The Author**

B. M. Laulhere, Jr., has been secretary-manager of Pacific Pipeline and Engineers, Ltd., since 1942. Entered pipelining about 1931, working at all kinds of jobs with contractors and coating companies and getting his schooling at the same time. In 1936 he went with Ingersoll-Rand as a student engineer.

He received his mechanical engineering degree from the University of California in 1938, joining Macco-Robertson Company the same year as an engineer with pipe line projects. He remained with the firm until he went with Pacific Pipeline and Engineers, Ltd. Laulhere is a director of Associated General Contractors of America, besides being a member of several technical organizations.

EXCLUSIVE

During the last decade, there have been great improvements made in the equipment used for the application of various pipe coating material, but in the case of the pipe coating materials themselves, there has not been so much change. In other words, the preponderance of pipe coating materials have been either coal tar or asphaltic base materials.

Recently considerable thought has been given to the use of plastic materials for coating pipe. So far as is known, in all cases where plastics have been used, the plastic material has been dissolved in a solvent and this solution sprayed on the pipe. This required long periods of baking in ovens or curing in the atmosphere with the result that as the solvent evaporated, fine pinholes or "holidays" were left in the coating. In order to procure an exceptionally impervious coating, this required the use of many coats, which added materially to the cost, slowed down the production rate, and practically made the use of plastic-coated field joints impossible under the circumstances.

Within the last two years, a new process has been developed in which the plastic material is fed into a stream of hot air. This air temperature is controlled to a temperature dependent on the melting point of the plastic material. As the plastic material is fed into the stream of heated air, it is brought to the fusion point and is then blown on the pipe to be coated. The thickness of the coating is controlled by the temperature of the heated air and very uniform thicknesses can be obtained. Samples of this material have been under test in the so-called "salt crock test" for a period of more than six months without the slightest sign of deterioration or resistance to the flow of current.

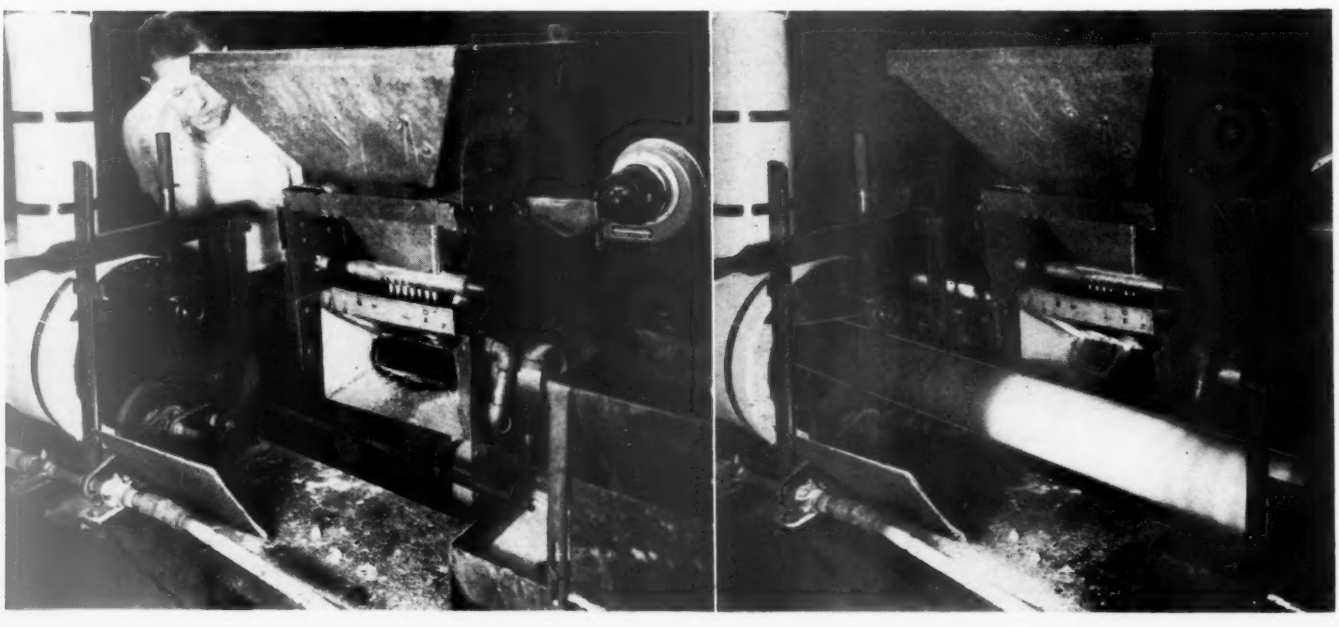
Although the "salt crock test" is not a final criterion of the life of a coating, it is known that materials having little or no protective value fail rapidly—in fact, in many cases in a matter of a very few days—and any material that stands up for a period of 30 days without showing any loss of resistance is considered worthy of further investigation. Any thermoplastic material can be used for this process, but to date all experiments have been conducted using Tennessee Eastman Corporation Tenite II because many thousand feet of gas service lines have been laid in the last few years using this material.

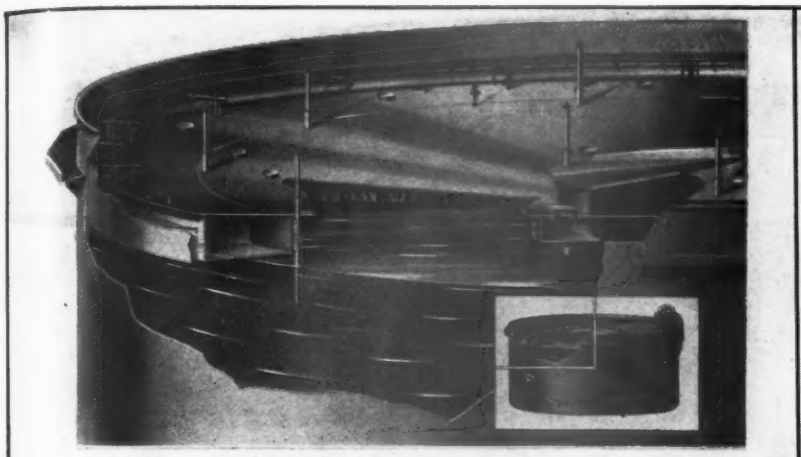
Pacific Pipeline and Engineers, Limited, of Los Angeles, are licensed applicators of this new process and are preparing to coat all sizes of pipe. In view of the success with plastic tubing in underground services and the manner in which the samples have stood up in the "salt crock test," this coating seems to us to be a forward step.

The coating is tough, stands abrasion and rough usage quite well. Due to the thin coating required to obtain adequate

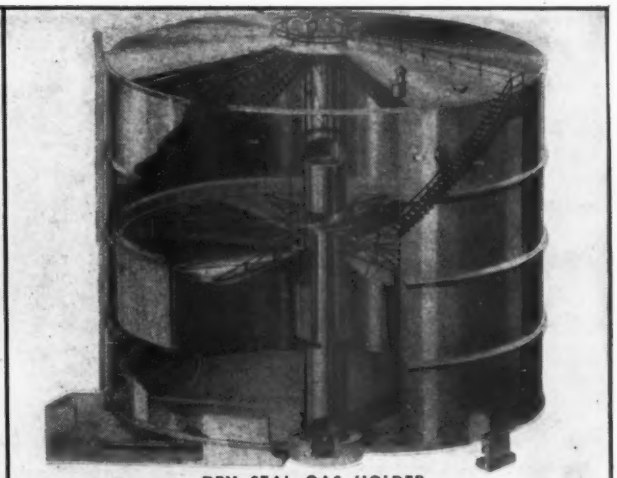
*Secretary-manager, Pacific Pipeline & Engineers, Ltd.

**View of plastic powder spray equipment in connection with the coating of a section of 4-in. steel pipe. At right the spray has produced a haze that blurs the photograph.**

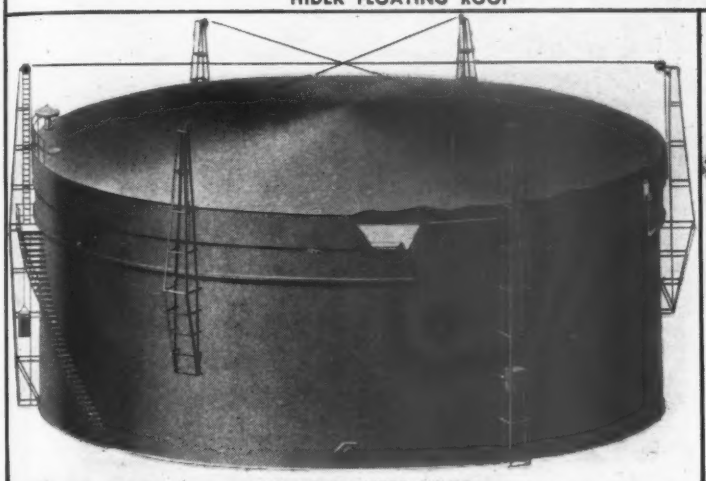




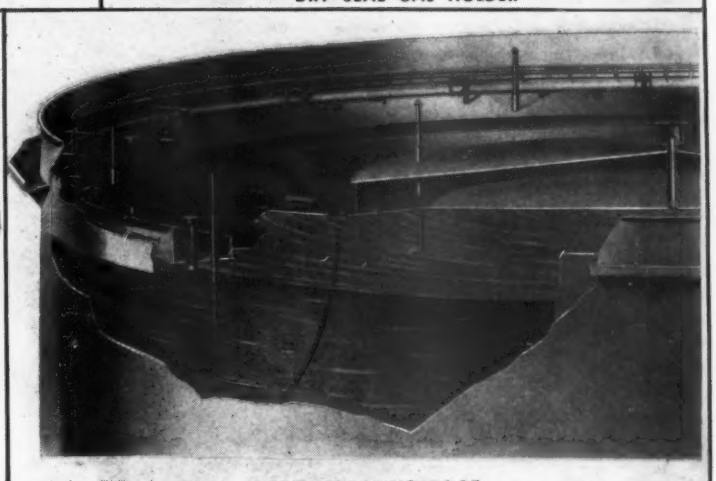
HIDEK FLOATING ROOF



DRY SEAL GAS HOLDER



DRY SEAL LIFTER ROOF



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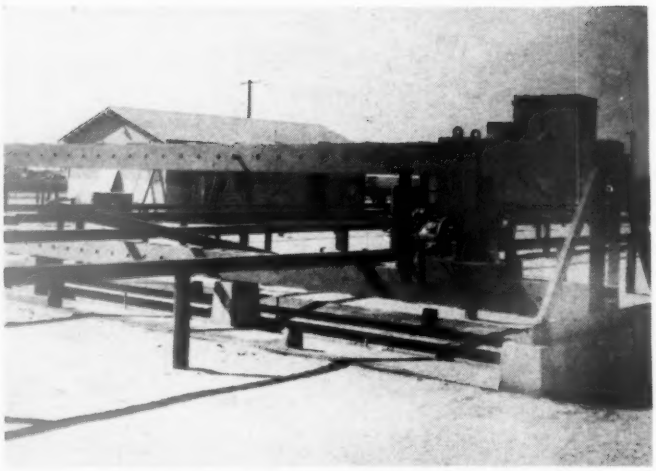
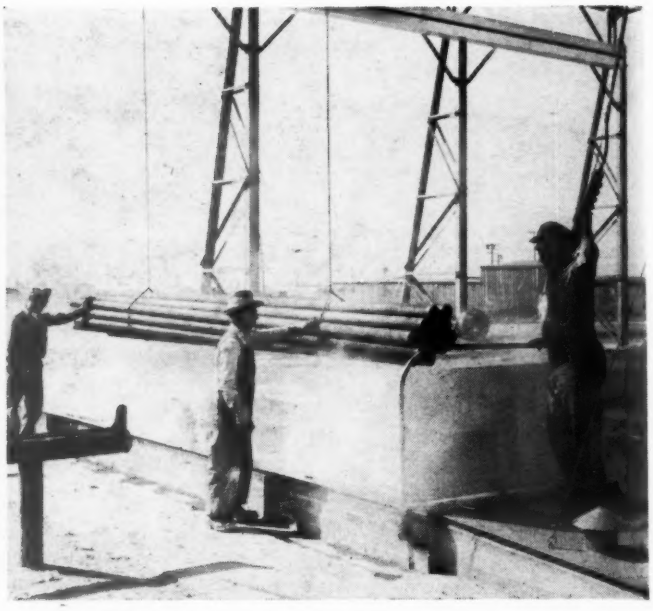
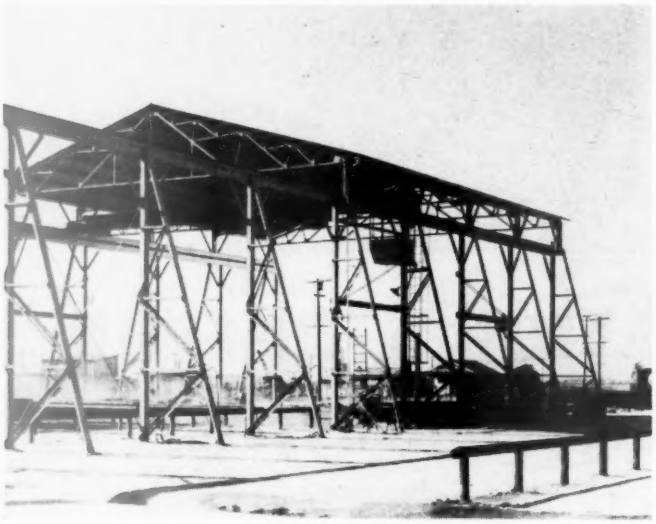


**Hydrostatic test machine for testing reconditioned pipe. Roto-blast equipment is shown in background. Particles in air hinder photographic reproduction.**



**Bundle of pipe ready to be dipped in hot asphalt.**



**Overhead crane serving pipe dipping operation.**

**View of adjustable inclined pipe cooling racks.**

protection, hauling costs are greatly reduced. The samples being tested, which to date have shown no deterioration, have a coating thickness of 0.05 in., which is equivalent to about 0.16 lb per sq ft or slightly more than ½ lb per lineal ft for 12¾-in. OD pipe. Experiments indicate that the pipe can be bent without causing holidays.

In addition to the plastic coating, Pacific Pipeline and Engineers, Limited, announces the inauguration of a new pipe reclamation and standard treating service, which embodies some of the most modern methods and equipment now available on the Pacific Coast.

The outstanding unit of this service is the company's new treating and reconditioning plant in Montebello, California. This plant, which occupies a paved area of approximately ten acres at 1632 South Greenwood Avenue, contains complete facilities for cleaning, straightening, testing, coating, and wrapping all diameters of pipe, from 2 in. to 30 in.

In the plant are 7500 lineal ft of racks for storage and processing of pipe. All machinery is operated by electricity or compressed air, which is supplied from central units through outlets at points throughout the entire plant.

Removal of coating from reclaimed pipe is accomplished by flame applied through torches fed with natural gas and oxygen. Cleaning processes are completed by interior sandblast and exterior rotoblast machines, after which corrosion pits are patched by spot welding. If required, ends of pipe may be torch scarfed, and short joints of pipe may be welded into long sections. A hydrostatic testing machine having a capacity of 1000 psi is available to assist in the proper grading of pipe.

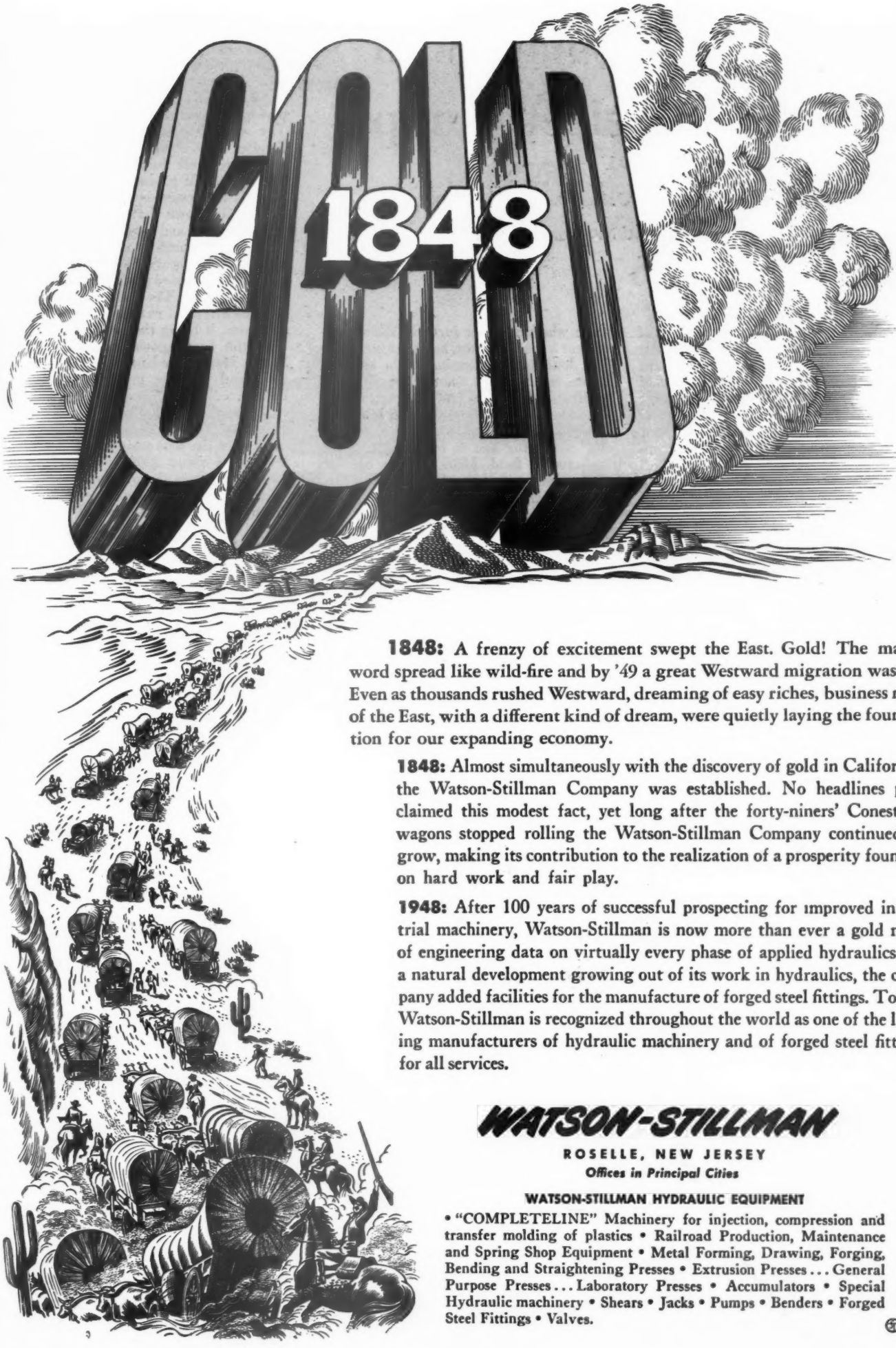
Application of coal tar and asphalt coatings is accomplished either by a continuous type machine having diameter capacities ranging from 4 in. to 30 in., or by a lathe type machine with capacities ranging from 2 in. to 26 in.

A 42-ft dip tank, with electrical temperature controls, provides a pipe dipping service capable of meeting customers' specifications accurately.

In addition to the permanent facilities available within the plant itself, the company has a complete line of portable pipe cleaning and wrapping equipment for use in the field. ★★★

☆ ☆ ☆

Fifty-eight oil fields of the United States have produced over 33,000,000 barrels of crude oil to date and have accounted for nearly 46 per cent of all the oil produced by all fields of the nation.—*The Petroleum Data Book*, Dallas, Texas.

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4131

# How to calculate well loads and select pumps

By A. ED. CARAWAY, *Dallas Division Manager,*
Lufkin Foundry and Machine Company

THERE is a tremendous accumulation of experience in selecting pumping units for oil wells, much of which would serve more to refine the original methods of calculating well loads than to change them to any great extent. The effect of many factors that could be considered is small, and if not offset by another conflicting factor in most cases, is small enough in relation to the total to have no appreciable effect on the final answer. To keep the subject from becoming too complicated only the basic factors will be discussed. To this end, the author has made an effort to present his and his company's experience on these problems without going into a highly technical and detailed discussion.

Some readers may not be in complete agreement with all methods and figures suggested. The methods are presented only after they have been discussed in detail with other engineers who have thoroughly studied them.

The thought involved in the selection of methods is generally based on experience gained under different circumstances. Each area, each field, and, in many cases, each well in a field may require a different approach to the selection of the proper equipment. The method is not so important, but it is necessary that the final solution and application be correct for a particular condition. The described methods have been found satisfactory in arriving at those correct answers and the proper applications.

For most well load calculations, the Slonneger formula, as approved by the API, is probably the simplest method for calculation of loads at average pumping speeds. Average pumping speeds refer to those below 20 spm. If pumping speeds above 20 spm are anticipated, the Mills formula is found to indicate a load nearer that found by checking actual operations with a dynamometer. The Mills formula is suggested for speeds between 20 and 25 spm, and the author thinks that a third formula is desirable for speeds above 25 spm. This, in effect, would suggest that either the Slonneger or the Mills formula is satisfactory on speeds below 20 spm.

The Mills formula with its higher impulse factor is suggested in the intermediate speed range of 20 to 25 spm. For wells pumping from 25 to 35 spm, which is an unusual operation and an extreme pumping speed, it is questionable whether either formula allows sufficient impulse factor, as speed increases the loading of pumping units and engines much faster than either formula indicates. For these fast pumping installations, it is suggested that the Mills impulse factor be applied to the weight of the rod string and to the weight of the column of fluid. Mills applies his impulse factor only to the weight of the rods. Thus:

$$\text{(Mills formula)}\quad P = WO + WR\left(1+\frac{SPM^2 \times \text{Stroke in inches}}{70{,}400}\right)$$

for 10 to 25 spm

Or:

$$\text{(Suggested Caraway formula)}\quad P = (WO + WR)\left(1+\frac{SPM^2 \times \text{Stroke in inches}}{70{,}400}\right)$$

for 25 to 35 spm

Where:

P = peak polished rod load, lb.
WO = weight of fluid lb = (plunger$^2$) (0.34) (depth)
WR = weight rod string, lb.

Our experience suggests that some impulse be allowed to start the column of fluid upward; however, it may be that the impulse factor suggested by Mills for application only to the rod string is sufficiently high to make some allowance for the fluid column at intermediate speeds below 25 spm.

Slonneger arrives at an impulse factor by using one plus spm, times length of stroke in inches, divided by 5400. This factor is applied to the total of the weight of the rods and of the column of fluid.

Thus:

$$P = (WO + WR)\left(1+\frac{SPM \times Stroke}{5400}\right)$$

Dynagraph cards confirm the suggestion regarding pumping speeds above 20 spm even though it may be questioned that loads are as high as would be indicated by the formula suggested for speeds greater than 25 spm. Experience in fields with high fluid levels and with considerable bottom hole pressure assistance would probably confirm the need for applying the impulse factor as suggested. The experience of those that have handled production in the older fields and lifted well fluid from bottom with no help would probably agree with the thought expressed in this article. Experience has shown that high speed, large fluid volumes, and long lift, subjects the pumping equipment to unusual loading. Comparative figures are shown, using the three suggested methods for calculating well loads. The East Texas field is used as a typical example for these calculations, it being the largest and probably the best known oil field in the States. Many have had experience in this area and will be interested in these figures.

Although wells in the East Texas field are about 3700 ft deep, a strong water drive from the west maintains a pumping fluid level above 2000 ft on most west side wells. Even though west side wells have a high fluid level, the fluid level on the east side of the field is not maintained as high by the water drive from the west and as a result the fluid in many wells is lifted from the bottom of the hole. It is necessary on some west side wells to lift 400 to 600 bbl of fluid to produce 20 bbl or less of oil. Wells on the east side of the field produce little or no water, and it is necessary to lift only the 20 bbl of "allowable" oil. This can be done with 8 to 12-hp pumping units using a short stroke and slow pumping speeds. West side wells are equipped with units in the 20 to 30 hp range with 48-in. to 54-in. stroke assemblies, and operate at 20 to 25 spm depending on percentage of water. Fluid levels vary from 1200 ft to more than 2500 ft, depending on differences in formation. although most of the west side wells cannot be pumped down below 2000 ft. The calculations in this comparison are based on the use of 2500 ft of ¾-in. rods with a 2¼-in. working barrel in 2½-in. tubing and 54-in. stroke pumping unit. A 2000-ft fluid level is assumed. From these figures, and from actual dynagraph loads, it is evident that pumping equipment in the 20-hp capacity should be sufficient for lifting 400 bbl.

Salt water disposal is an expensive item when water production is high and a majority of the East Texas operators do not find it economical to lift more than 400 bbl of fluid per day. When wells produce so high a percentage of water that they cannot be operated profitably while lifting a maximum of 400 bbl of fluid, the allowable is transferred, if possible, and the wells are soon abandoned.

| | 20 spm calculated | | | 25 spm calculated | | | 30 spm calculated | | |
|---|---|---|---|---|---|---|---|---|---|
| | Impulse factor | Peak beam load, lb | Peak torque, in.-lb | Impulse factor | Peak beam load, lb | Peak torque, in.-lb | Impulse factor | Peak beam load, lb | Peak torque, in.-lb |
| Slonneger..... | 1.2 | 8,650 | 93,500 | 1.25 | 9,000 | 97,000 | 1.30 | 9,360 | 101,000 |
| Mills..... | 1.3 | 8,440 | 91,000 | 1.48 | 9,200 | 99,500 | 1.69 | 10,040 | 108,500 |
| Caraway..... | 1.3 | | | 1.48 | 10,650 | 109,000 | 1.69 | 12,175 | 132,000 |

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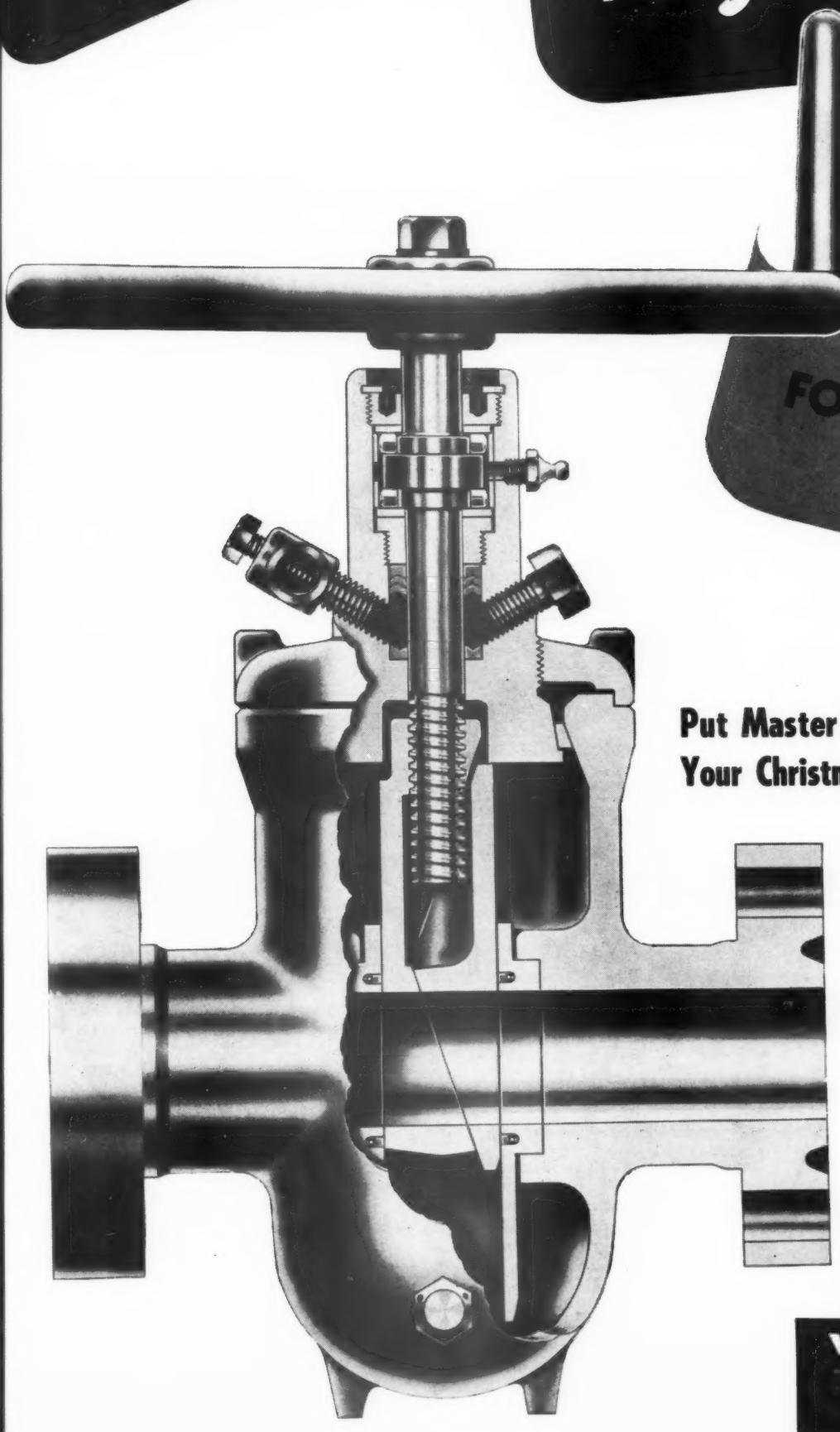

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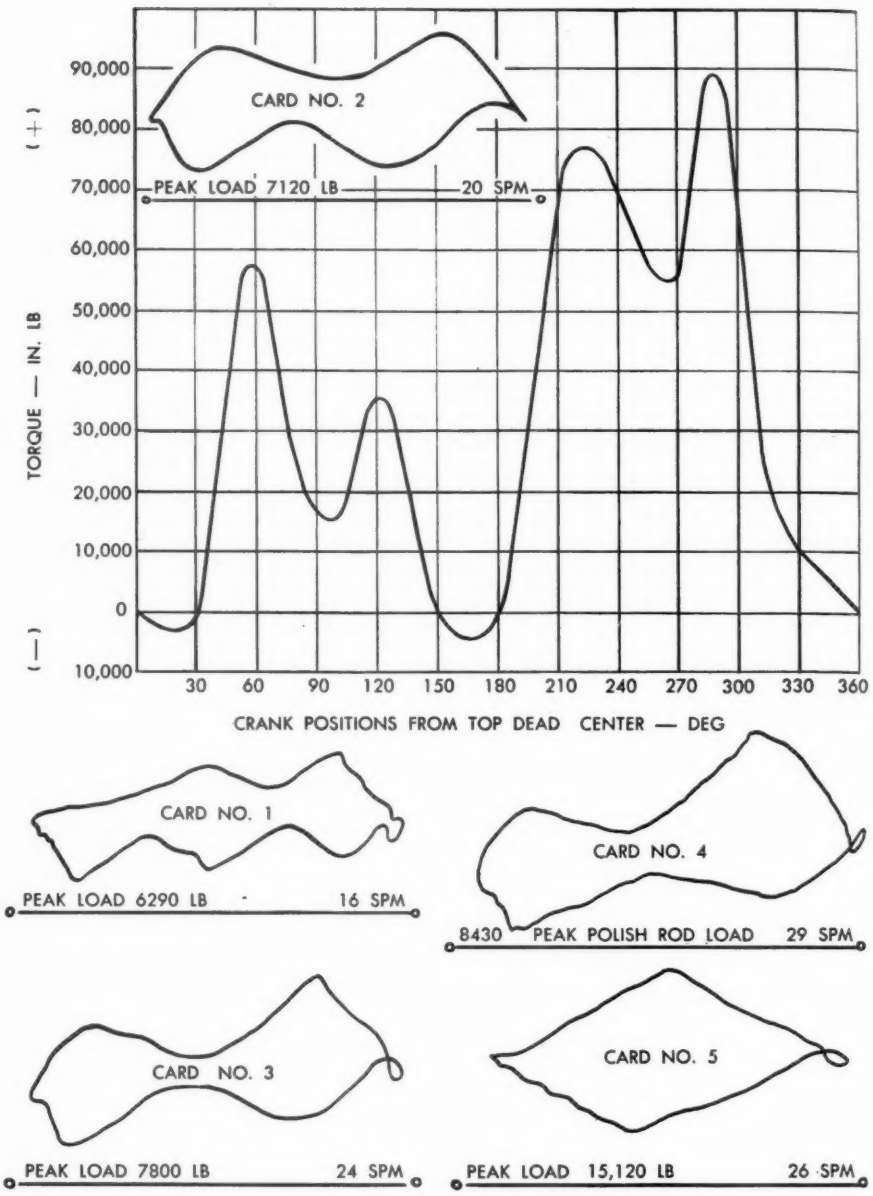
Some operators prefer to use 3000 ft to 3700 ft of rods and lift oil from the bottom rather than from higher in the hole, which would have a skimming effect. Bottom hole chokes have helped to reduce the water-oil ratio in East Texas wells when installed as soon as the wells began to make water. Operators believe from their records that the use of the bottom hole choke, which allows a small amount of fluid to settle out in the annular space between tubing and casing, has, in many instances, prolonged the productive life of wells as much as two years. Producing the small amount of oil and water that will flow into the annular space reduces the danger of coning and channeling large volumes of water into the well during its early pumping life.

Dynagraph cards have been taken at speeds of 25 to 35 spm that gave measured loads 30 to 60 per cent above the calculated loads for such operating conditions. Lacking a complete range of cards from 15 to 30 spm on any of those wells, it has been necessary to use the cards shown herein to give a full speed range comparison. Shown are the card and peak polished-rod load at 16 spm, at 20 spm, at 25 spm, and at 29 spm; however, cards and curves of other speeds on this well are available. These fit in about as interpolations would indicate. Compared to actual load at 29 spm measured with a dynagraph, it is found that the Slonneger calculated load is 17.5 per cent low. Compared to the measured load, the Mills calculated load is 9.5 per cent low, and the load calculated by the suggested impulse application is 7.4 per cent high. The bottom hole pump in the well on which these dynagraph cards were taken had been in operation almost seven months, and it is believed that operation in 98 per cent water for that period of time would wear the working barrel considerably. This wear would tend to produce smaller cards and would keep measured loads nearer the low figures of the calculated loads. A new working barrel might have shown higher loads, i.e., closer to the calculated loading, using the suggested (Caraway) formula.




**Dynagraph cards.**

| spm | Peak polished-rod dynagraph measured load, lb | Slonneger calculated load, lb 1500 ft fluid, 2000 ft rods | Mills calculated load, lb 1500 ft fluid, 2000 ft rods | (Suggested) Caraway calculated load, lb 1500 ft fluid, 2000 ft rods |
|---|---|---|---|---|
| 16 | 6290 | 6450 | 6220 | |
| 18 | 6630 | 6550 | 6380 | |
| 20 | 7120 | 6670 | 6560 | 7250 |
| 24 | 7800 | 6900 | 7040 | 8000 |
| 29 | 8430 | 7180 | 7700 | 9100 |
| Avg. percentage difference in calculated load and measured load..... | | —17.5 per cent | —9.5 per cent | —7.4 per cent |

These comparisons and the results of other dynagraph tests on high speeds confirm the belief that the third formula would be preferable for calculating loads for fast pumping operations. On these cards, which were used because of speeds from 16 to 29 spm on the same well, we get closer to the measured load by use of the larger impulse factor, which combines the weight of the fluid and rods. With the working barrel in better condition, it appears that the measured load and the calculated load by the suggested Caraway formula would have been very close. Dynagraph card No. 5 was taken on a well equipped with a 54-in. stroke unit pumping 26 spm. Twenty-six hundred ft of ¾-in. rods were run to the bottom of the well with a 2¼-in. working barrel in 2½-in. tubing.

Slonneger's formula allows a peak torque loading of 120,000 in.-lb for these condition. Mills' formula results in 121,000 in.-lb and a calculated torque of 148,000 in.-lb. Actually, the dynagraph card indicated more than 180,000 in.-lb torque. This card was taken on the Berg, Laney, and Brown lease, Cook well No. 3 in the Smackover field. This is an unusual load and would not be anticipated on all fast pumping wells. This unit was lifting dead oil and pounding fluid at the bottom of the hole. The unit and engine were severely overloaded although what was thought to be a safe allowance was made for those conditions of speed and high fluid volumes.

Dynagraph cards on any two wells may be different and exceptions will be found to any method; however, results on a large percentage of tests at these fast pumping speeds will bear out the calculations and comparisons shown above. Loads on wells in the Smackover, Arkansas, Mexia, Texas, and other old fields also confirm the suggestion that the Mills impulse factor should be

applied to the total of rod weight and fluid weight in calculating loads for the selection of pumping equipment where operators are pumping from 25 to 35 spm. Fluid levels are near the bottom of the hole and many wells pound fluid continuously. This adds considerable shock load to both the sucker rods and pumping unit, and it contributes to the fatigue that is set up in the equipment, causing premature failures. Experience shows the wisdom of assuming severe load conditions in recommending lifting equipment, and operators usually agree to the installation of equipment having sufficient capacity to care for such conditions. In some applications, we will agree that the full capacity of the equipment is never required. Fluid levels may remain high, and the bottom hole pressure may remain strong; however, late in the life of most production, these "lifting helps" are gone, and the equipment is lifting a "dead" load from the bottom of the well.

It should be emphasized that it is not a safe practice to buy pumping equipment smaller than calculations indicate. Although it is true that equipment is designed with a large safety factor, it is also true that manufacturers find this safety factor necessary to give the long, economical service that operators expect. Safety factors have probably been lowered in some cases in past years. It is believed that the rating of gears for pumping equipment is now as high as is desirable. It is desirable to rate equipment as high as it will operate satisfactorily and continuously, but when some of the safety factors that have been allowed are checked, trouble is given a hearty invitation to move in.

A step in the right direction was made when API and the American Gear Manufacturer's Association brought their rating formulas into agreement. The correlation had been studied for some time, was agreed on a year ago, and was adopted at the annual meeting of the API at Chicago in November, 1947. This will increase API ratings, but since API and AGMA are in agreement, rating formulas will probably remain unchanged for several years. Engine manufacturers and distributors are adopting the API suggested horsepower curve. There is a tendency to sell engines on the basis of their maximum hp curve rating, which is not satisfactory for application. Too often the operator assumes that an engine rated for 80 hp at top speed on the maximum curve can be installed to carry that load. Actually, the engine is rated and will produce only 35 to 40 hp continuously at operating speed, considering the Btu of the gas used and other correction factors that enter into the application. Such misapplication can be attributed to enthusiastic but inexperienced salesmen rather than to the manufacturer who wants applications that will allow the equipment to operate economically for a reasonably long period of time. The best provision against confusion on ratings and calculations is to select equipment from a reputable manufacturer who offers an engineered recommendation and application, and who can supply prompt and expert service with parts available immediately. A company that has built its reputation on good equipment, expert application, and dependable service cannot afford to allow the purchaser to make a serious application error.

At this point should be mentioned the fallacy of the use of "4950" as a method of correlating peak torque and horsepower. It has been accepted that nominal horsepower multiplied by 4950 gives peak torque in in.-lb based on a speed of 20 spm. This relation, however, was not suggested for speeds above or below 20 spm. Many of us are prone to use this conversion factor, however, and thus obtain incorrect applications. We assume peak torque should be used for the application of all pumping equipment rather than average hosepower or nominal horsepower. Several kinds of horsepower are misused interchangeably and, in the general discussion of equipment, tend to confuse many who have had neither the opportunity nor the time to make a complete study of all phases of production. Hydraulic horsepower is a familiar term with engineers. Polished-rod horsepower, in-put horsepower, nominal, and average horsepower have often been substituted for brake horsepower, or "just plain" horsepower. Average or nominal horsepower may be satisfactory on some applications of equipment that is for slow pumping on "normal" wells, but it is necessary to consider the load peaks in the selection of rods, pumping unit, and engine, especially when wells are operated at speeds above normal.

A reference was made earlier to the Smackover field. Load ranges similar to those found in other fields may be found in this area in Arkansas. A complete range of units from 5 hp to 117 hp is installed in this one field. Wells produce from four sands ranging from 2000 ft to 2600 ft in depth. Production ranges from 2 or 3 bbl to as much as 2000 bbl of fluid per day. The units are operating at speeds ranging from 5 spm on stripper wells to 35 spm on high fluid volume wells that use 3-in. tubing with 2¾-in. working barrels and 74-in. to 120-in. strokes.

Savings have been effected by replacing 6-ft stroke pumping equipment with units having a 9-ft or 10-ft stroke on high volume wells. Reduction in rod reversals has materially lengthened the life of the subsurface pumps, sucker rods, and tubing. It was also found that power costs were reduced as much as 25 per cent in some instances where 6-ft stroke units operating at 30 spm were replaced by 9-ft stroke units operating at 20 spm. The same amount of fluid was produced.

☆ ☆ ☆

Stanolind Oil and Gas Company will participate in drilling 948 wells at a cost of about $69 million this year, E. F. Bullard, president, announced. Last year the company participated in drilling 844 wells at a cost of $50.6 million. Of these, 509 net wells were drilled by Stanolind, according to its annual report.

Most of this equipment is powered by electric motors. It was also found on both stripper wells and large volume wells that operating costs dropped materially when individual pumping units replaced standard rigs or band wheel powers. Records indicate that the cost of the new equipment, including motors and installation, was paid back in an average period of 2.43 yr by reduction of down-time, saving on labor costs and materials, and by increased production.

Proper counterbalancing was an important factor in the use of electric motors. Counterbalancing is necessary to keep gear load peaks as low as possible and to keep power costs at a minimum. Adjustable type counterbalances tend to reduce the need for winch trucks and extra men to change the weights. Several manufacturers now offer adjustable counterbalance cranks on which counterweights can be handled and adjusted easily by the pumper.

It may be inviting criticism from the "engine" men in presenting our methods for applying engines to pumping loads, and some will not agree with the "rule of thumb" method we find satisfactory. If the cubic displacement of a multi-cylinder engine is divided by 15, a horsepower capacity figure will be obtained that will be very close to the output of the engine at its operating speed. For example, 334 cu in. displacement divided by 15 gives about 22½ hp for an application. As a 4-cylinder engine has a normal operating speed range of 900 to 1200 rpm, it would suggest operating the engine at 1000 rpm for 20 spm. Experience shows that an engine of this size will handle economically an actual load of 20 to 25 hp for an extended period of time.

In applying engines, it must be taken into consideration also that there is usually a loss of 30 per cent or more from engine to polished rod, so, if you have a 20-hp load at the polished rod, an engine of about 30 hp should be used to handle this load satisfactorily. On engine loads as on pumping unit loads, peaks must be considered. Average horsepower applications may not allow sufficient capacity to handle the peak loading to which the engine will be subjected. An overload condition may exist causing premature failure, although the average load may indicate that the equipment has sufficient capacity.

Engine manufacturers use and suggest formulas similar to the one shown here for application of their product to pumping loads:

$$\text{Bhp} = \frac{D^2\ LS\ \text{spm}}{600{,}000}$$

Where:

D = pump size
L = depth, and
S = stroke length

In selecting engines by this formula, it is suggested that the API rating curve on the engine be used or multiply the maximum horsepower shown at the correct operating speed by a factor of 0.65 to get maximum engine capacity for application to pumping loads. ★ ★ ★

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# Corrosion costs in the petroleum industry

By F. A. ROHRMAN, *Executive Director*, Engineering
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EXCLUSIVE

THE petroleum engineer recognizes the necessity for studying corrosion, which exerts its influence from the moment crude oil is pumped from a well to the time when the refined products are distributed or stored. Everyone is cognizant of the fact that petroleum or its refined products are not corrosive in themselves. The normal companions of these hydrocarbons cause most of the difficulty. These are water, salt, oxygen, carbon dioxide, and sulphur. During later stages of refining the use of sulphuric acid, hydrofluoric acid, and other added agents contribute to further responsibility for the costly corrosion mechanisms.

The present-day necessity for strict and accurate cost control and analyses makes it desirable to attribute definite charges to the common enemy—corrosion. The realization that corrosion costs included items more remote and costly than equipment destruction, replacement, and maintenance added considerably to the need for corrosion abatement or mitigation. Corrosion costs in the petroleum industry can be attributed to the following cost factors:

1. Equipment replacement or repair.
2. Lost time through shutdowns owing to replacement or repair.
3. Inspection and maintenance charges.
4. Cost of corrosion prevention other than routine maintenance.
5. Loss of processed or conveyed material.
6. Extra heat or power to maintain flow.
7. Damages or suits caused by ruptures or breaks.
8. Cost of research.

It is necessary to realize that all these factors add to the cost of corrosion. It is simple to charge equipment replacement or even seasonal painting to the corrosion ledger. A more difficult charge to visualize is the steady, integrated, and accumulating costs arising from extra power required to pump a unit of material through a pipe whose smooth surface gradually corrodes or builds up a resisting corrosion film. It seems desirable then to consider the above factors individually so that the cost of corrosion can be determined more accurately.

● **Equipment replacement or repairs.** For years the cost of corrosion has been attributed to the cost of replacing or repairing the equipment or plant destroyed by corrosion. No doubt replacements run into millions of dollars annually. The frequency of replacing plant and equipment depends upon the type of the equipment as well as the type of crude oil being processed. The amortization or depreciation rate of a condenser differs from that of sucker rod or bubble cap and the corrosion problems involved in the refining of a West Texas crude may be quite different from the same operation on a Pennsylvania crude. Experience in one locality may differ considerably from that in another. Thus seacoast refineries have some corrosion problems differing from inland refineries.

Fig. 1 shows a corroded exchanger bundle taken from a stabilizing unit handling pressure distillate from cracking stills. The unstable pressure distillate was on the shell side. It is obvious that this unit must be replaced. Frequent replacements would be a severe cost item.

It is fairly simple for the accountant to attribute corrosion charges to replacements and repair after several years of experience at one location.

● **Lost time through shutdowns.** Any loss in time or production due to corrosion can be determined easily and charged to corrosion. Such losses can add up to extensive charges. In the past a break in normal operation has caused either a lay off of certain employes or their shift to other duties. Where useful services can be employed upon other duties or projects such transfers are not so costly other than the factors of interrupted time and slow readjustment to new duties.

The question of delayed production can be quite serious if a normal flow of products is needed by an over-demanding consumption. It is not unusual for one company to purchase refined stock from a competing company in order to tide over the unbalance between supply and demand. During the

**FIG. 1. Corroded exchanger bundle taken from stabilizing unit handling pressure distillate.**

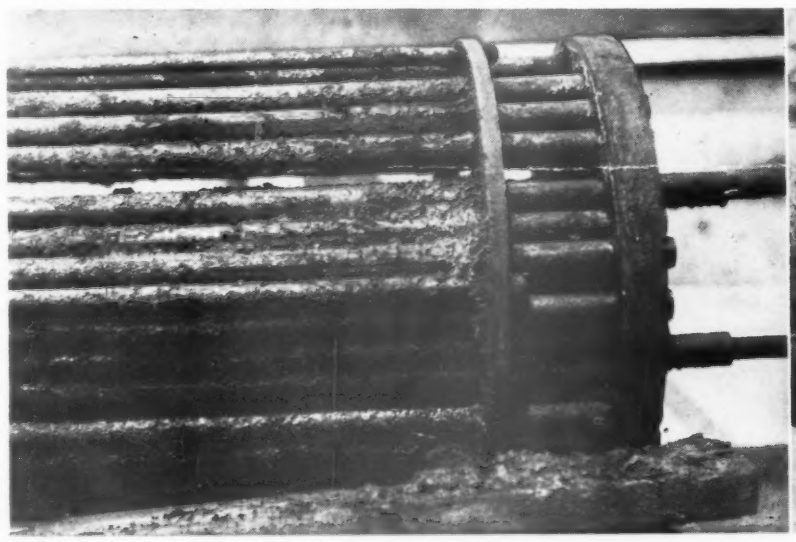

**FIG. 2. Close-up of corroded 8-in. oil pipe line from soil attack.**

**FIG. 3. Typical tank farm of 55,000-bbl tanks. Such tank roofs give 2 to 5 years service with sour oils.**

last war any interruptions in production bordered upon treason.

● **Inspection and maintenance.** Inspection and maintenance offer one of the first and most important barriers to corrosion damage. Constant inspections discover weaknesses caused by corrosion that can be quickly remedied, and thereby save considerable time and money. Periodic painting is a necessity for all iron and steel structures. The frequency of painting depends upon the locality. A seacoast installation might require painting every year whereas a Tulsa, Oklahoma, or Casper, Wyoming, location may require painting once in two or more years. The use of a gunite coating on tanks gives a good cost comparison of protective coatings versus corrosion. The average sour crude will destroy an unprotected tank in from 3 to 10 years. An application of gunite coating will cost about 50 per cent the original cost of the tank. This coating then will more than double the life of the tank.

One of the problems of corrosion in the petroleum industry is that it can exert its influence both within and without. Thus a pipe line or tank is subject to the elements on the outside as well as those inside. In one case exterior corrosion may be more severe than interior corrosion, whereas in another case interior attack may be greater than exterior. Figs. 2 and 3 illustrate these examples. The 8-in. pipe line suffered pitting and selective soil attack on the exterior whereas the interior was hardly corroded by the crude it transported. The tank farm is typical of the case where the interior might become badly corroded by sour oils and rupture in a few years. Maintenance can do little for a buried pipe line whereas maintenance can be applied to the interior and exterior of a tank by frequent applications of protective coatings. Spot inspections can reveal expected corrosion of buried lines. Experiences of several organizations indicate that the cost of repairing a buried pipe can be from $150 to $600 per leak.

The recent practice of repairing worn or corroded parts by metallizing is receiving favor with several companies. By this means, metal can be sprayed on the worn and corroded part, restoring it to its original thickness. Such a means is much less expensive than total replacement and also enables immediate salvage whereas a long delay may be necessary for replacement.

It has been estimated that maintenance costs are largely labor costs and with the high cost of labor one can see that this factor is a serious one. A good painting job requires more than mere paint application. Considerable labor is involved in preparing the surfaces to accept the paint.

● **Cost of corrosion prevention.** There are a number of ways to prevent or mitigate corrosion other than by routine maintenance. One must realize, however, that such means also cost money and require a certain amount of attention. Some of the commonest means of corrosion prevention are by the use of protective coatings or application other than paints, by chemical treatment of petroleum oils, water, or soil, by cathodic protection, and by the use of resistant alloys.

Everyone is familiar with the mechanical means for covering pipe with organic and inorganic wrappers. The character of the soil may or may not demand such thorough protection but where its application is employed external corrosion by acid soil is prevented. The cost of such application may run from 50 cents to several dollars a foot, depending upon the pipe size and thickness of application, but damage that would cost considerably more, as indicated by Fig. 2, is prevented. It is known that unprotected pipe in some locations has corroded to the point of perforation in less than six months. The cost of repair or replacement in such a case is many times that of wrapped and treated pipe. Other advantages of protective wraps and coatings is that thinner walled pipe can be used, thus effecting a decided saving in steel tonnage. Also, the scrap value of protected pipe is much higher than that of unprotected pipe, and cathodic protection is more effective and simplified.

**FIG. 4. Corroded ends of oil well tubing.**

Crude oil has been treated with inhibiting agents, cooling water with phosphates or alkalies, and soils with lime to halt corrosion. Any sour crude will cause destruction of wing valves, choke tips, sucker rods, and oil well tubing. Fig. 4 shows some badly corroded tubing after a short period of use in a sour crude well. The adding of inhibiting agents to water has received considerable attention the last few years. Some of these agents consist of chromates, phosphates, silicates, and various kinds of organic chemical agents. The use of any specific inhibitor depends upon the particular installation and local conditions. In some instances any inhibitor may be successful and in other instances only certain ones will be practicable. A number of inhibitors are available at the present time and do much to prevent corrosion at a low cost.

The recent method of dehydrating the refined product prior to its entering the pipe line has proved to be a money saver. The presence of moisture in the product induced internal corrosion. The use of inhibitors did not prove practicable, hence the possibility of removing the objectionable water was next considered. This was accomplished with a drying agent and the method proved economical and practicable.

Cathodic protection, sacrificially with magnesium, aluminum, or zinc, or by superimposing a direct electric current, is being used in many installations today. Such protection depends upon metals like magnesium, aluminum, or zinc being preferentially attacked rather than iron or steel or by the use of an outside source of direct current, which is applied so that the normal destructive corrosion currents are reversed. The choice of one of these metals or the use of the electric current depends upon many considerations. Briefly, the sacrificial metals offer a cheap but expendable means of protection, whereas the d-c generator offers continuous protection but at a higher initial cost. Cathodic protection can be accomplished for several hundred dollars a mile.

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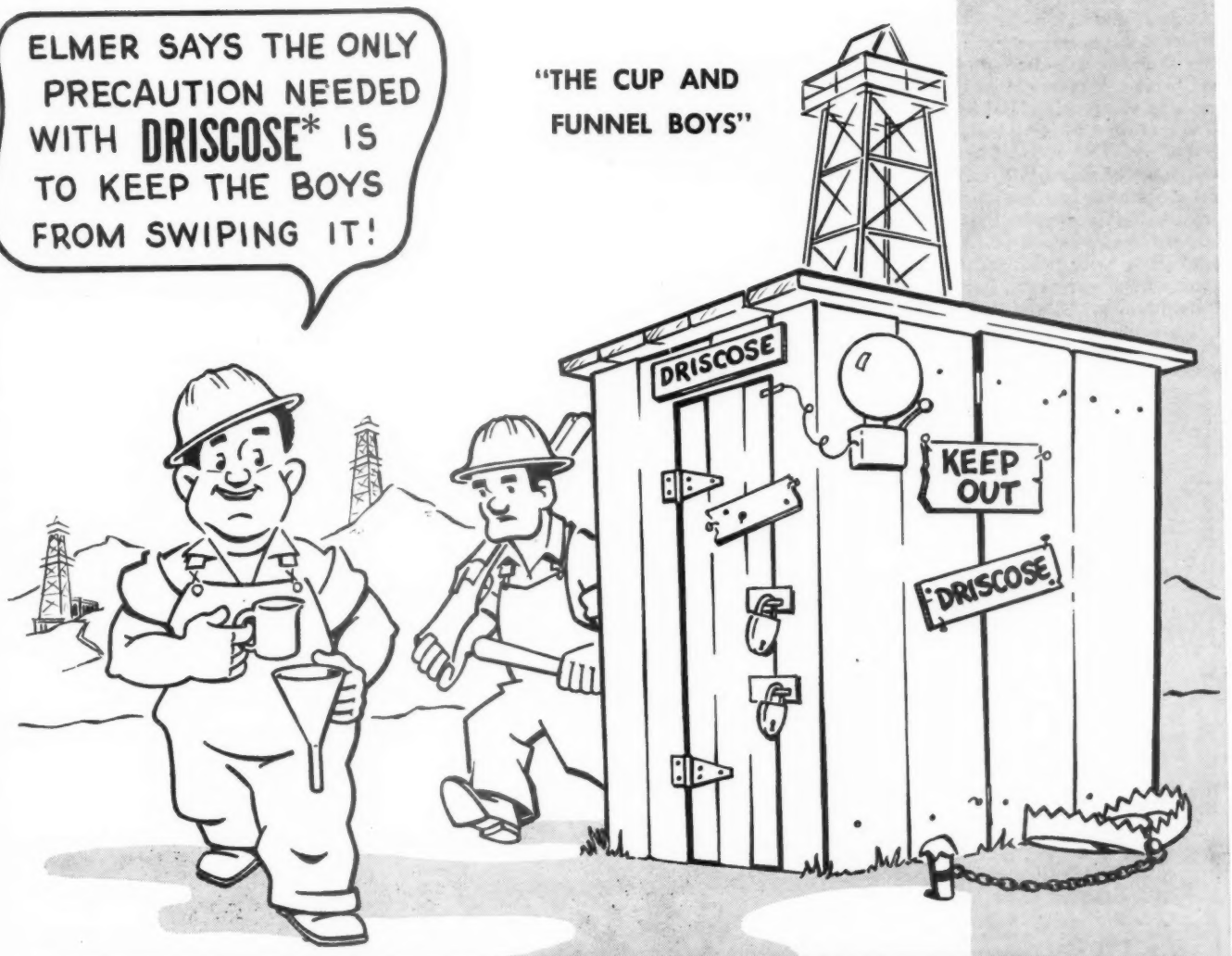


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ment may favor one or the other. It would be difficult to say which of these metals or means is to be preferred. Each situation might indicate one or the other. The fact is, cathodic protection works and works economically. Fig. 5 shows two sets of zinc slabs bolted on the web of a cast-steel floating head of a closed condenser. The tube of the condenser was made of Admiralty metal and electrolytic action had set up between the two dissimilar metals, brass and steel, causing deterioration of the steel. The zinc slabs will now act to take the brunt of the corrosion, being preferentially attacked. Later inspection will indicate replacement of zinc as its protective value is dissipated by corrosion. Aluminum or magnesium would perform the same type of service.

The use of alloys is well known in the petroleum industry. Condenser and exchanger tubes of brass, cracking tubes of low chromium steel and 18-8 stainless, and Monel metal for HF are common examples. A sour crude will destroy low carbon steel cracking tubes in one to six months; the use of 4-6 chromium or chromium-nickel tubes increases the life of such tubes several times more than the added initial cost imposes. The use of high cost and high quality stainless steel tubes may not be the answer to some installations. One case has been cited where "18-8" furnace tubes failed after 100 hr of service.

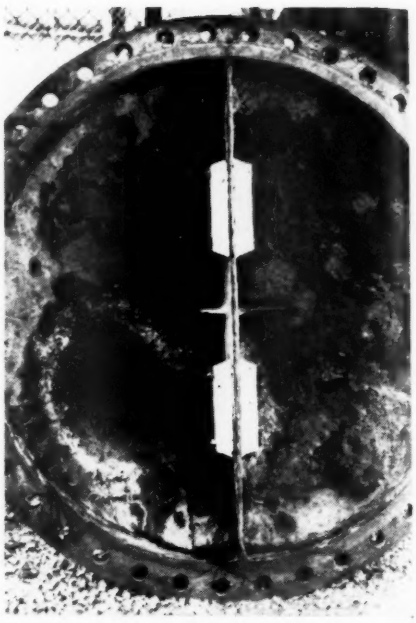

**FIG. 5. Two sets of zinc slabs on web of condenser floating head.**

Considerable attention can be directed to design characteristics in order to mitigate corrosion. The old practices relative to the use of dissimilar metals in contact with each other are now being eliminated when possible. These evils still persist in many pieces of apparatus and equipment to the eventual concern of the maintenance engineer. In some instances the presence of bimetallic couples cannot be avoided. In such cases the engineer should have the advantage of knowing the presence of such weak spots and be prepared for the potential trouble. Periodic inspections for possible replacements is the only satisfactory answer.

Design insofar as shape and form are concerned often can be utilized to advantage. The use of flat roofs for tanks so that they can be wetted with crude oil periodically seems to answer some of the roof tank corrosion problems. Tanks and equipment should be so designed that they can be drained and cleaned periodically. The accumulation of water or corroding media in pockets or sumps always invites localized corrosion. The need for ease in removing parts of equipment is apparent when such parts are subject to corrosion.

● **Loss of conveyed or processed material.** How much crude oil, gas, or refined petroleum products are lost through leaks and ruptures caused by corrosion is difficult to estimate. It would be interesting to conduct a material balance on several integrated producing and refining units over a period of several years. Some gasoline line leaks have permitted more than 90 per cent of the conveyed material to escape. It is realized that any major rupture resulting in large losses would soon be detected and rectified. Small losses through leaks con-

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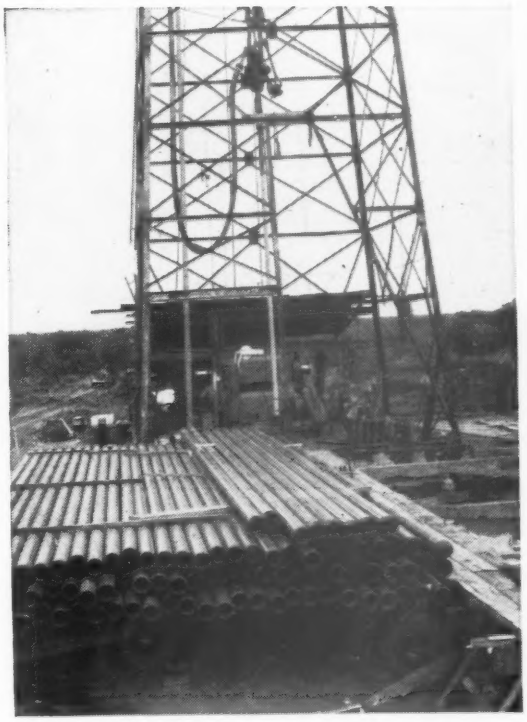

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ceivably could go on for years without detection. The accumulation of losses in all phases of the industry could run into an appreciable amount.

Leakage through corrosion may also cause contamination that can affect finished products seriously. Such an undesirable situation can result from passing crude and products through exchangers that may corrode.

The financial losses sustained when pipe line leaks cause crude oil or refined products to spill over sources of water used for drinking, or on land used for pasture, are other items to be considered. Presumably many organizations have been unfortunate enough to encounter law suits or litigation because of corrosion carelessness. Two cases have been cited where one leak resulted in $20,000 costs and damages. It would be interesting to trace the various accountants' entries for such costs.

● **Heat and power to maintain flow.** One of the important factors that determines the rate of flow of fluid or heat through a pipe is that of surface conditions. A smooth, clean surface encourages streamline flow and possesses a more favorable film for the flow of heat. If the surface of metal has become rough, pitted, or covered with corrosion products the fluid flow rate and heat flow rate will be greatly reduced. Knowing that it requires energy to pump fluids through pipes and knowing that films will reduce the efficiency of heat flow through exchangers, tubes, etc., it is easy to see that additional energy is required to force fluids or heat through corroded materials of construction.

It would be difficult to assess any definite sum to the energy cost of a pumping, piping, or refining operation chargeable to corrosion. The cost would be a variable one because an old system would be more extravagent than a new system and certain portions of any system would deteriorate faster than others. Furthermore, the experience in California would differ from that of Oklahoma or Pennsylvania. For the average system one could safely charge 10 per cent of the total heat and pumping energy to corrosion effects after each year of operation. Such figures would add up to considerable losses and might lead one to doubt their validity. It is only necessary to examine the steam and power plant records against production to verify this estimate. It would be interesting, indeed, to establish a case history for some integrated unit over a long period of time.

● **The cost of research.** Considerable money has been spent on the research, testing, and development of means to counteract corrosion. Although some of these costs have not produced tangible results, many have. In one instance research indicated that a certain chemical inhibitor would reduce oil well corrosion caused by hydrogen sulphide. The inhibitor was added and the number of failures was reduced so that nearly 3,000 per cent saving was effected. The fact is that corrosion research has paid off many times the original charges by the discovery and development of the many known means for mitigating or preventing corrosion.

As a conclusion, one can safely say that the cost of corrosion in the petroleum industry goes far beyond the cost for replacement, repair, or maintenance. It is difficult to say what extra charge for gasoline or fuel oil is made because of corrosion but there is a good reason to believe that it is close to 10 per cent.

The writer wishes to thank the many organizations that contributed data to make this article possible. Credit is due The Gulf Oil Corporation, Phillips Petroleum Company, Standard Oil Company (Indiana), and others. ★ ★ ★

### Atomic oil?

Dr. T. R. Hogness of the University of Chicago recently discussed the use of the atom bomb in oil fields. Exploding a bomb at the bottom of a dry well might make it produce, he said. Channels through which the oil flows might be enlarged and a large area drained through one well.


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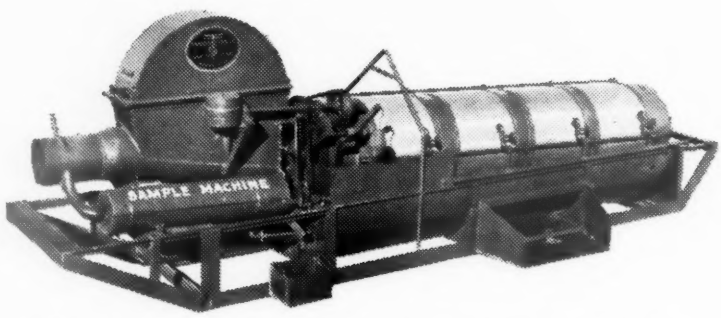


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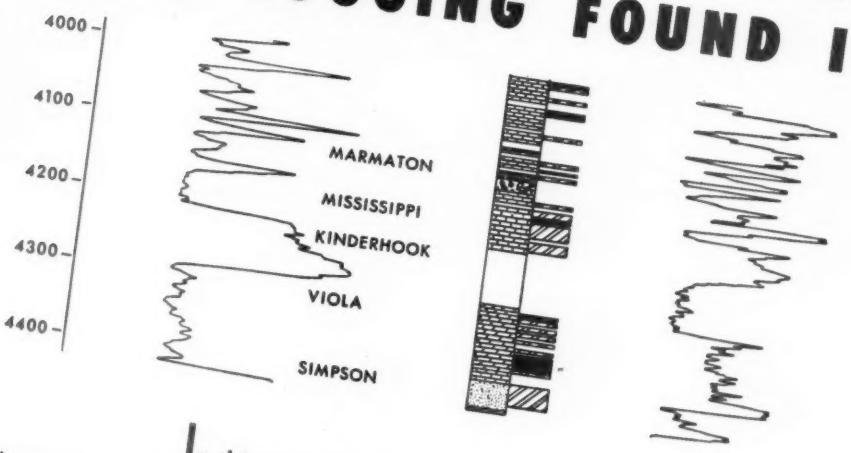


In this area, the principal oil producing strata is the Simpson sandstone, directly above which is the gas-producing Viola lime, with no shale break between. To locate and define the formations, and to indicate zones of porosity, Lane-Wells ran a Combination Log: the contact between the Simpson and the Viola, barely discernible on the Gamma Ray Curve, is clearly marked on the Neutron Curve. Dual completion was based on the log, and both zones gun perforated. Initial potential of this well is 10 MCF gas from the Viola, 3,000 BOPD from the Simpson.

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# Processing Pennsylvania crude

By DAVIS READ, Universal Oil Products Company

THE production of motor gasoline from Pennsylvania crude presents some refining problems that are not common to the majority of other crudes. One of the principal reasons for this, of course, is the fact that the heavier fractions of the crude, which would normally be cracked to increase the yield and quality of motor fuel in refineries processing other types of crude, are utilized more advantageously in the manufacture of lubricating oils and waxes by Pennsylvania refiners. Accordingly, the ratio of high octane number cracked gasoline, produced from gas oil cracking, to the lower octane straight run fractions produced is decreased. In addition, the Pennsylvania straight run gasoline cuts are quite paraffinic and relatively low in octane rating and volatility and are processed under rather severe conditions to enable the average Pennsylvania refiner to meet specifications in present overall gasoline blends. As a result of these situations any further increase in octane rating that might be required is, in general, more difficult to achieve by changes in the operation of the existing thermal equipment than is normally the case in other refineries.

The purpose of this study is to present a summary of certain data available on the processing of Pennsylvania crude with particular reference to methods of increasing the yield and octane rating of the gasoline and the yields of distillate fuels produced.

It might well be asked why it is necessary to be concerned with increasing octane rating today when the demand for gasoline and all petroleum products is so high and, in fact, it seems that the problems of increasing crude throughput or finding more crude to process are more important immediate factors to be considered. There is, of course, evidence to be examined on both sides of the question of increased gasoline octane rating. As A. P. Frame stated in a recent paper entitled "A Refiner's Look at Gasoline Quality," the final judge of whether octane numbers will increase will be the public; that is, whether the public will demand improved fuels to be used in the new high compression automobile engines that are being developed. Only the future can answer this. In the present market, however, there can be little doubt about the desirability of increasing the production of distillate fuels so long as this can be done without sacrificing the production of more valuable products.

**TABLE 1. Properties of Pennsylvania crude.**

| | |
|---|---|
| Gravity, °API | 44.5 |
| Specific gravity at 60 F | 0.8040 |
| Sulphur, wt. per cent | 0.07 |
| BS&W, per cent | Trace |
| Cold test, °F | −5 |
| Kinematic viscosity at 100 F cts. | 3.19 |
| Universal viscosity at 100 F sec. | 36.6 |
| Salt as sodium chloride, lb/1000 bbl | 4 |
| Characterization factor | 12.4 |
| 100 ml distillation | |
| IBP, °F | 155 |
| 5 | 213 |
| 10 | 240 |
| 20 | 295 |
| 30 | 354 |
| 40 | 425 |
| 50 | 508 |
| 60 | 585 |
| 70 | 660 |
| 80 | 708 |
| 90 | 733 |
| E. P., °F | 750 |
| Per cent over | 99.0 |
| Per cent coke by wt. | 0.8 |
| Composition, liquid vol., per cent | |
| Propane | 0.1 |
| Butanes | 0.5 |
| Pentanes to 115 F | 1.7 |
| Fraction boiling above 115 F | 97.7 |
| Total | 100.0 |
| Fraction boiling above 115 F | |
| Gravity, °API | 43.5 |
| Specific gravity | 0.8086 |

● **Properties of Pennsylvania crude.** Table 1 presents the results of an inspection of a sample of crude from the Bradford field and Table 2 shows a laboratory Hempel distillation analysis of the crude in which both a 225 F end point and a 400 F end point straight run gasoline were removed overhead and inspected. A sample of full range gasoline produced in the commercial distillation of Bradford crude was further analyzed by laboratory Hempel distillation as shown in Table 3. Rather complete inspections were obtained on gasoline fractions having end points of 225 F, 275 F, and 325 F and these data are plotted on Fig. 1. It will be noted that the properties of the 225 F end point gasolines listed in Tables 2 and 3 are slightly different due to differences in the degree of fractionation encountered in the two methods of preparation. The straight run gasolines are low in sulphur content and have good lead susceptibility as would be expected.

● **UOP thermal reforming.** The thermal reforming operation is widely used

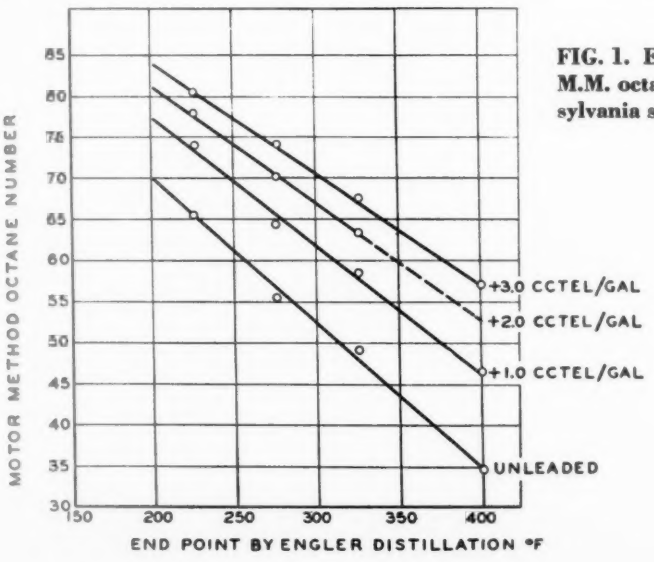


**FIG. 1. Effect of end point on M.M. octane number of Pennsylvania straight run gasoline.**

**TABLE 2. Laboratory fractionation of Pennsylvania crude.**

| Breakup number | 1 | 2 | |
|---|---|---|---|
| Yields, vol. per cent of crude | | | |
| Light gasoline 225 F. EP | 9.0 | | |
| Naphtha 225-400 F | 29.5 | 38.5 | |
| Topped crude | 61.1 | 61.1 | |
| Recovery | 99.6 | 99.6 | |
| Loss | 0.4 | 0.4 | |
| Properties of fractions | 225 F EP gaso. | 225-400 F Naphtha | 400 F EP gaso. | Topped crude |
| Gravity, °API | 76.9 | 57.0 | 60.9 | 35.7 |
| Specific gravity | 0.6790 | 0.7507 | 0.7354 | 0.8463 |
| Mercaptan sulphur, per cent | 0.001 | 0.006 | 0.005 | .. |
| Total sulphur, per cent | 0.05 | 0.06 | 0.07 | 0.08 |
| BS&W, per cent | | | | 0.1 |
| Cold test, °F | | | | 35 |
| Kinematic vis. at 100 F cts. | | | | 13.43 |
| Universal vis. at 100 F sec. | | | | 71.2 |
| Vapor pressure, Reid, lb | 12.8 | | 3.7 | |
| Octane number Motor Method | 63.5 | 31 | 38 | |
| Characterization factor | 12.55 | 12.15 | 12.22 | 12.37 |
| 100 ml distillation | | | | |
| IBP, °F | 92 | 227 | 100 | 430 |
| 5 | 109 | 237 | 163 | 470 |
| 10 | 119 | 244 | 185 | 483 |
| 20 | 134 | 260 | 217 | 513 |
| 30 | 146 | 272 | 239 | 559 |
| 40 | 155 | 284 | 257 | 606 |
| 50 | 164 | 297 | 275 | 653 |
| 60 | 174 | 313 | 293 | 689 |
| 70 | 184 | 329 | 311 | 708 |
| 80 | 192 | 346 | 337 | 722 |
| 90 | 202 | 365 | 365 | 750 |
| EP., °F | 227 | 405 | 402 | 760+ |
| Per cent over | 97.5 | 99.0 | 98.0 | 98.5 |
| Per cent bottoms | 1.0 | 1.0 | 1.0 | .. |
| Per cent coke by wt. | .. | .. | .. | 1.3 |
| Per cent loss | 1.5 | .. | 1.0 | .. |

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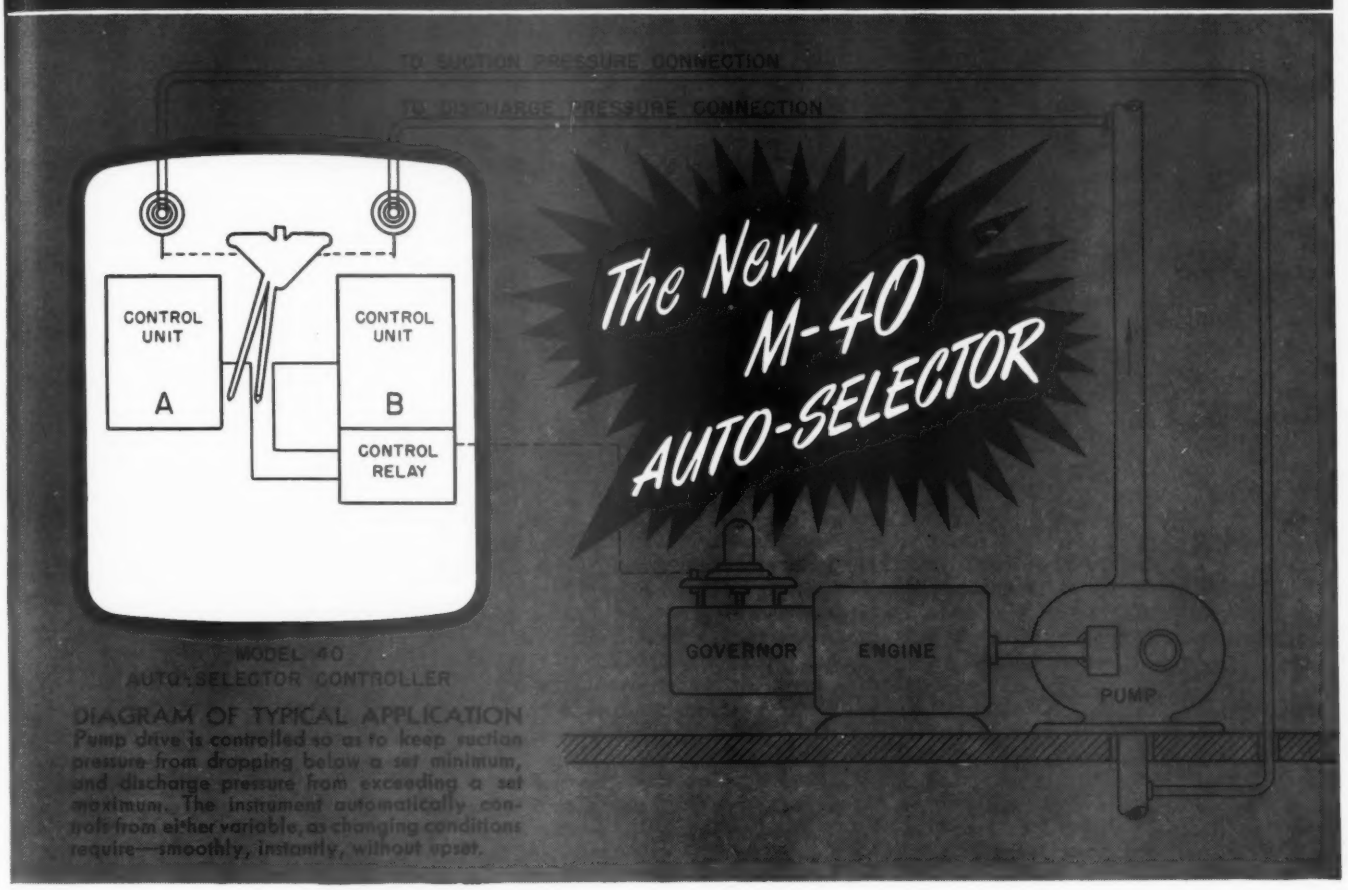
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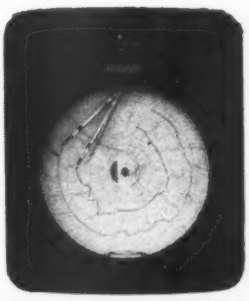

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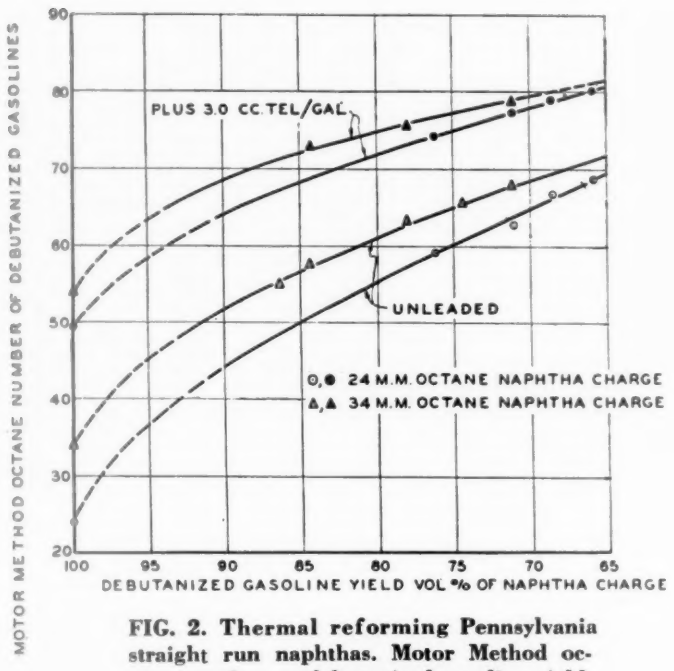
MOTOR METHOD OCTANE NUMBER OF DEBUTANIZED GASOLINES
PLUS 3.0 CC TEL/GAL
UNLEADED
O,● 24 M.M. OCTANE NAPHTHA CHARGE
Δ,▲ 34 M.M. OCTANE NAPHTHA CHARGE
DEBUTANIZED GASOLINE YIELD VOL % OF NAPHTHA CHARGE

**FIG. 2. Thermal reforming Pennsylvania straight run naphthas. Motor Method octane number vs. debutanized gasoline yield.**

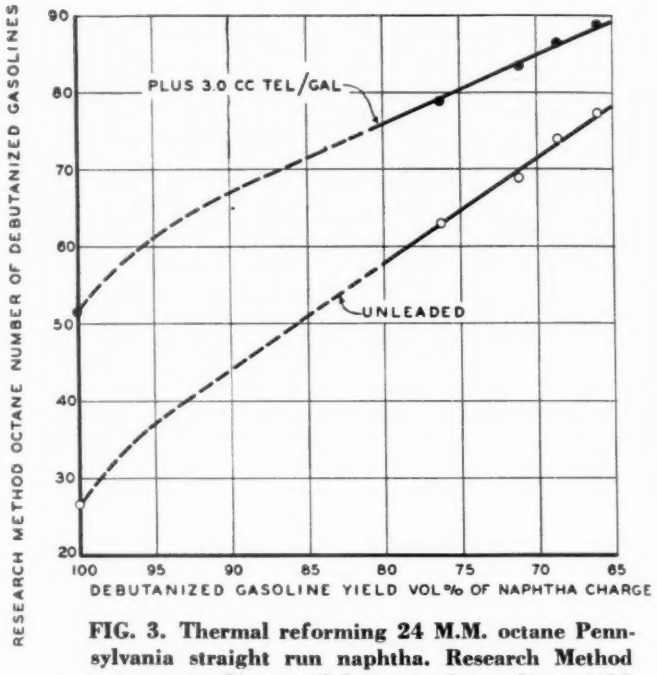
RESEARCH METHOD OCTANE NUMBER OF DEBUTANIZED GASOLINES
PLUS 3.0 CC TEL/GAL
UNLEADED
DEBUTANIZED GASOLINE YIELD VOL % OF NAPHTHA CHARGE

**FIG. 3. Thermal reforming 24 M.M. octane Pennsylvania straight run naphtha. Research Method octane number vs. debutanized gasoline yield.**

by Pennsylvania refiners for processing straight run naphtha fractions either in a light oil coil operated in conjunction with a thermal cracking unit or in a separate reforming heater. Although it is possible to reform severely, if necessary, to increase octane rating, the attendant loss in gasoline yield is at times prohibitive. A careful study of the reforming operation often reveals that the overall liquid recovery can be increased without sacrifice in gasoline quality or, conversely, that overall gasoline quality can be improved without sacrifice in production by certain changes in methods of processing. Selection of the proper gasoline fraction to be reformed and the conversion level at which the reforming operation is carried out are two important factors to be considered.

Pilot plant data obtained in thermal reforming two Pennsylvania naphthas are given in Tables 4 and 5. The gasoline yield octane data are presented on the basis of producing approximately 10-lb RVP gasolines in Table 5, and the results are shown graphically in Figs. 2 and 3 on the basis of producing debutanized reformed gasolines. It is apparent from these graphs that it is more advantageous, from the standpoint of overall barrel octanes, to process all the heavy naphtha that is available for gasoline blending at an intermediate or low conversion level rather than to process only a part of the same naphtha at high conversion level. For example, from Fig. 2, 100 bbl of 25-octane naphtha can be reformed to yield 90 bbl of 43-octane debutanized gasoline, whereas if only 50 bbl of naphtha are reformed to an 80 per cent yield and blended with 50 bbl of unreformed naphtha the resulting 90 bbl of blend will have an octane number of only approximately 38. The corresponding polymer plus butane yields will be practically the same in the two cases.

The selection of charging stock for the reforming operation has considerable bearing on the overall octane number picture. In most cases studied it

**TABLE 3. Laboratory fractionation of full range Pennsylvania gasoline.**

| | 1 | | 2 | | 3 | |
|---|---|---|---|---|---|---|
| Break-up number | | | | | | |
| EP of light gasoline, F | 225 | | 275 | | 325 | |
| Yields, volume per cent of gasoline | | | | | | |
| Light overhead | 21.0 | | 46.3 | | 70.4 | |
| Naphtha bottoms | 78.5 | | 53.2 | | 29.2 | |
| Recovery | 99.5 | | 99.5 | | 99.6 | |
| Loss | 0.5 | | 0.5 | | 0.4 | |
| Properties of fractions | Light overhead | Naphtha bottoms | Light overhead | Naphtha bottoms | Light overhead | Naphtha bottoms |
| Gravity, °API | 77.9 | 55.4 | 68.7 | 52.8 | 64.0 | 50.4 |
| Specific gravity | 0.6757 | 0.7571 | 0.7068 | 0.7678 | 0.7238 | 0.7779 |
| Vapor pressure, Reid, lb | 10.8 | | 6.0 | | 4.8 | |
| Mercaptan sulphur, per cent | 0.006 | | 0.002 | | 0.002 | |
| Total sulphur, per cent | 0.05 | 0.06 | 0.05 | 0.06 | 0.05 | 0.06 |
| ON Motor Method clear | 65.5 | 23.5 | 55.5 | 16 | 49 | 5 |
| +1cc TEL/gal | 74 | | 64.5 | | 58.5 | |
| +2cc TEL/gal | 78 | | 70 | | 63.5 | |
| +3cc TEL/gal | 80.5 | | 74 | | 67.5 | |
| ON Research Method clear | 67 | | | | | |
| +1cc TEL/gal | 75.5 | | | | | |
| +2cc TEL/gal | 79 | | | | | |
| +3cc TEL/3 gal | 81 | | | | | |
| Characterization factor | 12.59 | 12.15 | 12.32 | 12.11 | 12.23 | 12.10 |
| 100cc distillation | | | | | | |
| IBP, °F | 91 | 240 | 108 | 298 | 119 | 340 |
| 5 per cent | 112 | 258 | 147 | 311 | 163 | 350 |
| 10 per cent | 121 | 266 | 159 | 317 | 178 | 352 |
| 20 per cent | 131 | 276 | 176 | 323 | 197 | 355 |
| 30 per cent | 141 | 287 | 188 | 330 | 212 | 357 |
| 40 per cent | 148 | 300 | 198 | 337 | 225 | 361 |
| 50 per cent | 156 | 316 | 208 | 345 | 237 | 366 |
| 60 per cent | 164 | 332 | 218 | 354 | 250 | 372 |
| 70 per cent | 172 | 348 | 227 | 365 | 262 | 379 |
| 80 per cent | 182 | 366 | 237 | 379 | 275 | 388 |
| 90 per cent | 198 | 388 | 250 | 395 | 294 | 402 |
| EP, °F | 225 | 417 | 276 | 420 | 325 | 422 |
| Per cent over | 98.0 | 99.0 | 98.5 | 99.0 | 98.5 | 99.0 |
| Per cent bottoms | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| Per cent loss | 1.0 | | 0.5 | | 0.5 | |

**TABLE 4. UOP thermal reforming Pennsylvania straight run naphthas. Properties of charge stocks.**

| Stock | 24 MM octane naphtha | 34 MM octane naphtha |
|---|---|---|
| Gravity, °API | 55.1 | 53.8 |
| Total sulphur, per cent | 0.06 | 0.04 |
| Mercaptan sulphur, per cent | 0.002 | .. |
| Octane numbers | | |
| F-2 Motor Method | 24 | 34 |
| +1cc TEL/gal | 36.5 | 45 |
| +2cc TEL/gal | 43.5 | .. |
| +3cc TEL/gal | 49.5 | 54 |
| F-1 Research Method | 26.5 | .. |
| +1cc TEL/gal | 38 | .. |
| +2cc TEL/gal | 45.5 | .. |
| +3cc TEL/gal | 51.5 | .. |
| Characterization factor | 12.15 | 11.98 |
| 100 ml distillation | | |
| IBP | 238 | 247 |
| 5 per cent | 260 | 263 |
| 10 per cent | 270 | 268 |
| 20 per cent | 285 | 277 |
| 30 per cent | 292 | 285 |
| 40 per cent | 305 | 293 |
| 50 per cent | 319 | 304 |
| 60 per cent | 334 | 317 |
| 70 per cent | 349 | 330 |
| 80 per cent | 366 | 344 |
| 90 per cent | 387 | 362 |
| EP, °F | 417 | 409 |

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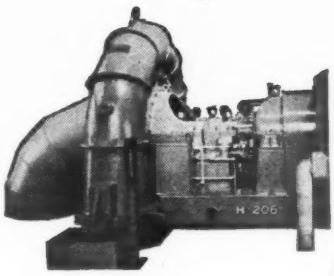

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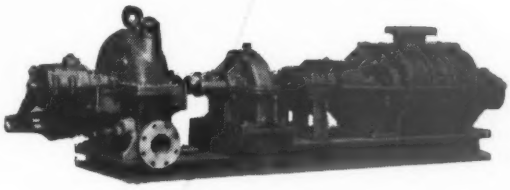
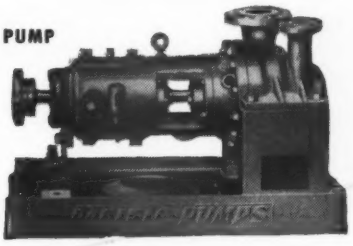
| Exhausters | Roots-Connersville |
| Inert Gas Generators | Roots-Connersville |



● ROOTS-CONNERSVILLE—ROTARY POSITIVE EXHAUSTER

● PACIFIC—CENTRIFUGAL PUMP



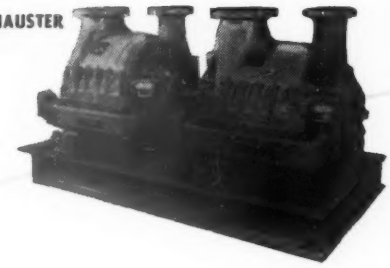


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**TABLE 5. UOP thermal reforming Pennsylvania straight run naphthas. Yields and properties of products.**

| Charge stock | 24 MM ON naphtha | | | | 34 MM ON naphtha | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Test number | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 5 |
| Yields, per cent of naphtha charge | | | | | | | | | |
| Reformed gasoline, vol. per cent | 84.0 | 78.5 | 75.3 | 71.1 | 93.5 | 91.2 | 85.5 | 82.5 | 78.4 |
| Residue, vol. per cent | 3.5 | 3.2 | 3.2 | 3.8 | 0.7 | 1.1 | 1.7 | 2.0 | 2.2 |
| Gas, cu ft per bbl charge | 412 | 550 | 651 | 756 | 223 | 290 | 433 | 504 | 605 |
| Properties of gasoline | | | | | | | | | |
| Gravity, °API | 59.8 | 59.2 | 58.3 | 58.3 | 57.3 | 57.5 | 58.2 | 57.7 | 56.5 |
| Total sulphur, per cent | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 |
| Mercaptan sulphur, per cent* | 0.014 | 0.014 | 0.014 | 0.012 | .. | 0.017 | 0.011 | .. | 0.012 |
| Reid vapor pressure, lb | 10.0 | 9.5 | 11.7 | 10.9 | 9.2 | 10.2 | 9.6 | 9.5 | 9.6 |
| Octane numbers | | | | | | | | | |
| F-2 Motor | 62.5 | 65.5 | 69.0 | 71.0 | 58.5 | 61.0 | 66.0 | 68.5 | 70.5 |
| +3.0 cc TEL/gal | 76.5 | 79.5 | 81.0 | 82.0 | .. | 75.0 | 77.5 | .. | 80.0 |
| F-1 Research | 67.0 | 72.5 | 77.5 | 80.0 | | | | | |
| +3.0 cc TEL/gal | 82.0 | 86.0 | 89.0 | 91.0 | | | | | |
| 100 ml distillation | | | | | | | | | |
| IBP, °F | 96 | 85 | 91 | 90 | 104 | 106 | 99 | 102 | 98 |
| 50 per cent | 273 | 262 | 256 | 254 | 285 | 282 | 270 | 268 | 266 |
| 90 per cent | 365 | 363 | 359 | 366 | 366 | 371 | 350 | 355 | 360 |
| EP, °F | 393 | 400 | 392 | 400 | 393 | 398 | 384 | 390 | 401 |
| Composition, liquid volume per cent | | | | | | | | | |
| $C_3$ fraction | 0.3 | .. | .. | .. | .. | 1.1 | 0.4 | .. | .. |
| Butylenes | 5.0 | 5.3 | 5.2 | 5.4 | .. | 4.3 | 5.2 | 5.6 | 5.2 |
| Butanes | 4.2 | 4.6 | 4.8 | 4.7 | .. | 3.1 | 3.9 | 4.9 | 4.5 |
| Pentanes and heavier | 90.5 | 90.1 | 90.0 | 89.9 | .. | 91.5 | 90.5 | 89.5 | 90.3 |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | .. | 100.0 | 100.0 | 100.0 | 100.0 |
| Properties of residue | | | | | | | | | |
| Gravity, °API | 25.5 | 21.0 | 15.7 | 15.6 | .. | 24.1 | 21.6 | 18.0 | 14.3 |
| 100 ml distillation | | | | | | | | | |
| IBP, °F | 417 | 424 | 414 | 375 | .. | 406 | 443 | 454 | 460 |
| 5 per cent | 441 | 448 | 448 | 427 | .. | 452 | 482 | 485 | 487 |
| Composition of gas, mol. per cent | | | | | | | | | |
| Hydrogen | 2.5 | 2.0 | 4.2 | 3.4 | .. | 3.2 | 3.1 | 3.4 | 2.8 |
| Methane | 20.8 | 20.1 | 21.9 | 24.2 | | 21.0 | 20.3 | 19.6 | 21.5 |
| Ethylene | 5.4 | 4.5 | 5.1 | 4.0 | | 6.2 | 5.2 | 4.6 | 4.6 |
| Ethane | 23.6 | 21.0 | 23.3 | 23.4 | | 25.8 | 25.0 | 20.2 | 21.3 |
| Propylene | 18.1 | 16.7 | 14.6 | 14.1 | | 18.1 | 18.7 | 18.7 | 17.1 |
| Propane | 23.4 | 26.2 | 19.5 | 19.3 | | 18.0 | 21.6 | 27.8 | 24.1 |
| Butylenes | 3.1 | 4.4 | 5.1 | 4.5 | | 2.3 | 2.2 | 2.4 | 3.9 |
| Butanes | 2.0 | 3.8 | 4.5 | 3.9 | | 1.5 | 1.8 | 1.9 | 3.5 |
| $C_5$ fraction | 1.1 | 1.3 | 1.8 | 3.2 | | 3.9 | 2.1 | 1.4 | 1.2 |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | | 100.0 | 100.0 | 100.0 | 100.0 |

*Before sweetening.

has been shown that it is more advantageous to prefractionate the full range gasoline and reform only the heavy naphtha than to reform the full range gasoline. Although no data are given in this paper to confirm this on Pennsylvania stocks, it has been shown that prefractionation of a 400 F end point full range Mid-Continent straight run gasoline and reforming of the 250-400 F naphtha resulted in an increase of 2 to 5 points in Motor Method octane rating as compared with thermally reforming the full range gasoline to the same overall yield. Aside from gaining a better overall yield octane relationship, however, possibly an even greater advantage resulting from the elimination of light fractions from the reforming charge is the increased heater capacity made available for additional heavy naphtha reforming.

● **UOP thermal cracking.** Data are given in Tables 6 and 7 to show the results obtained by pilot plant two-coil thermal cracking a 37.6-deg API gravity Pennsylvania gas oil. The yields obtained in this test are somewhat higher and the octane number is somewhat lower than would be expected in present commercial operation since a 400 F end point gasoline was produced in the pilot plant while the usual commercial practice at present is to undercut the gasoline to possibly 370 F end point to increase octane rating to 67-68. Both the thermally cracked and reformed gasoline are low in sulphur and are readily sweetened by treatment with copper sweetening reagents. In this connection it might be mentioned that if copper is left in the gasoline, a product of improved stability is obtained by the use of metal deactivators, which chemically combine with the copper and possibly the iron present and minimize the oxidation of the gasoline in storage. A simple test to determine the concentration of deactivator required is carried out by determining the induction periods of samples of the same inhibited gasoline containing a normal amount of inhibitor plus varying amounts of metal deactivator. A good starting point is to use about 0.0005 per cent deactivator. In this way data can be obtained to plot a curve of induction period vs. concentration of deactivator. The point at which the induction period begins levelling off corresponds to the concentration of deactivator that should be used.

● **Fluid catalytic cracking.** Tables 8 and 9 contain recent data obtained in high conversion fluid catalytic cracking a 40.4-deg API gravity Pennsylvania gas oil. In this operation the reactor temperature was maintained at 900 F and the fraction boiling above gasoline was recycled at a ratio of 2:1 on fresh feed. An overall yield of 84.4 per cent of 10-lb RVP gasoline, including polymer, was obtained. The octane ratings of the total gasoline, including polymer, would be 80.5 by the Motor Method or 89.5 by the Research Method unleaded. It should be mentioned that even higher Research Method octane can be obtained by operating the fluid reactor at higher temperatures if necessary.

The cycle oil produced from the 40-deg API gravity 624 F end point charge stock in this operation had an API grav-

**TABLE 6. UOP two-coil thermal cracking Pennsylvania gas oil. Properties of charge stock and yields.**

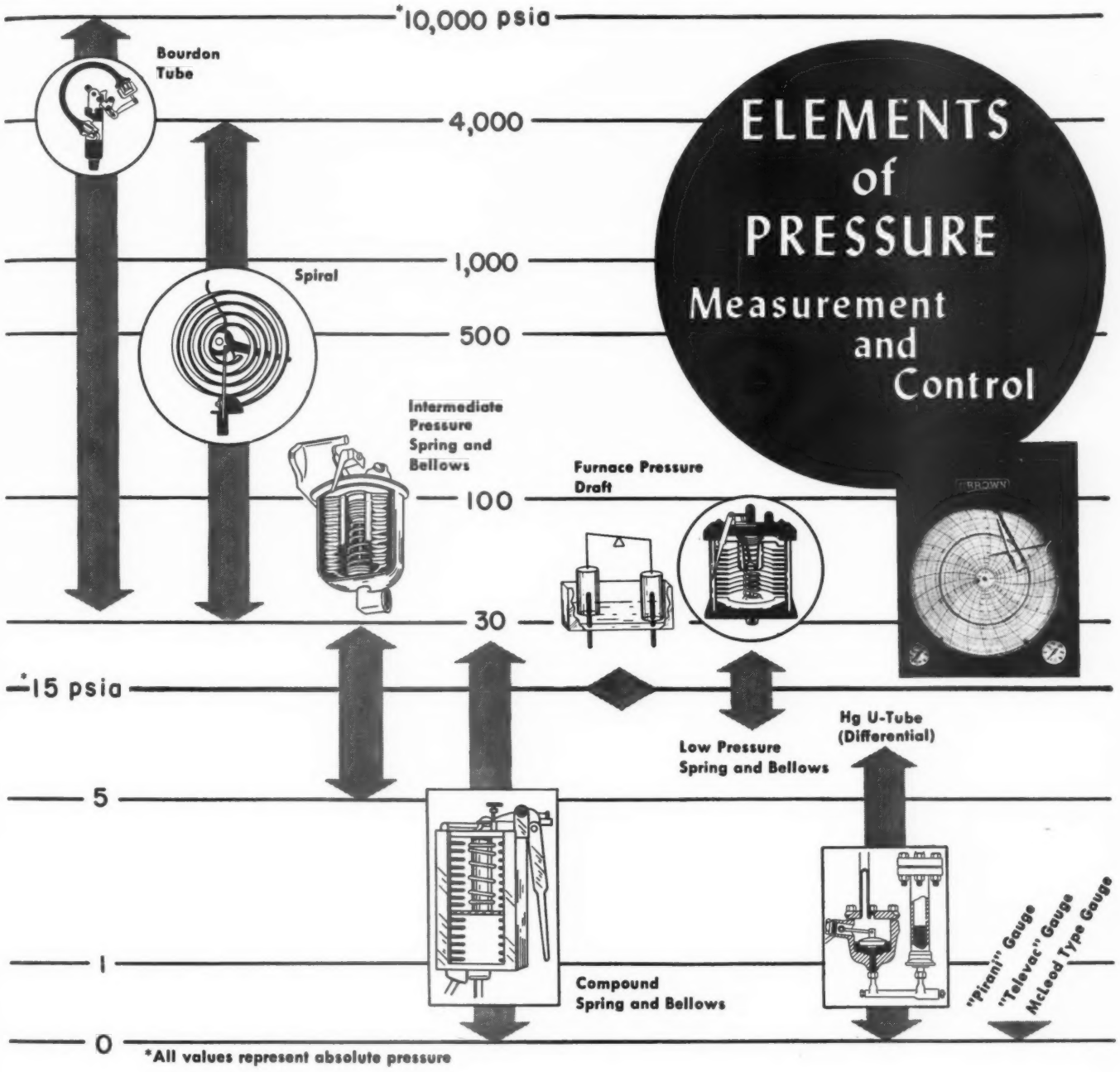
| | |
|---|---|
| Properties of charge stock | |
| Gravity, °API | 37.6 |
| Specific gravity at 60 F | 0.8368 |
| Sulphur, wt. per cent | 0.05 |
| Cold test, °F | +15 |
| Universal viscosity at 100 F sec | 45.5 |
| Characterization factor | 12.20 |
| 100 ml distillation | |
| IBP, °F | 446 |
| 10 per cent | 506 |
| 30 per cent | 556 |
| 50 per cent | 597 |
| 70 per cent | 642 |
| 90 per cent | 707 |
| Yields, per cent of cracking unit charge | |
| Ethane and lighter gases, cu ft/bbl charge | 268 |
| Propylene, liq. vol., per cent | 4.4 |
| Propane, liq. vol. per cent | 7.7 |
| Butylenes, liq. vol. per cent | 5.8 |
| Butanes, liq. vol. per cent | 6.2 |
| 400 F EP gasoline, vol. per cent | |
| Debutanized basis | 68.1 |
| 10 lb RVP basis | 73.5 |
| Residuum | 15.5 |

**TABLE 7. UOP two-coil thermal cracking Pennsylvania gas oil. Properties of products.**

| | |
|---|---|
| Composition of ethane and lighter gases, mol. per cent | |
| Hydrogen | 7 |
| Methane | 43 |
| Ethylene | 7 |
| Ethane | 43 |
| Total | 100 |
| 10-lb RVP gasoline (untreated) | |
| Gravity, °API | 61.0 |
| Mercaptan sulphur, wt. per cent | 0.005 |
| Total sulphur, wt. per cent | 0.02 |
| Reid vapor pressure, lb | 10 |
| Octane numbers | |
| F-2 Motor clear | 66 |
| +1.0 cc TEL/gal | 72.5 |
| +3.0 cc TEL/gal | 77.5 |
| F-1 Research clear | 72.0 |
| +1.0 cc TEL/gal | 80.5 |
| +3.0 cc TEL/gal | 85.5 |
| 100 ml distillation | |
| IBP, °F | 95 |
| 10 per cent | 135 |
| 30 per cent | 195 |
| 50 per cent | 253 |
| 70 per cent | 304 |
| 90 per cent | 361 |
| EP, °F | 396 |
| Residuum | |
| Gravity, °API | 11.1 |
| BS&W, per cent | 0.1 |
| Universal vis. at 100 F, sec | 430 |
| Furol vis. at 122 F, sec | 24 |

**TABLE 8. UOP fluid catalytic cracking Pennsylvania gas oil. Properties of charge stock and yields.**

| | |
|---|---|
| Properties of charge stock | |
| Gravity, °API | 40.4 |
| Specific gravity at 60 F | 0.8232 |
| Sulphur, wt. per cent | 0.05 |
| Conradson carbon on 10 per cent botts., per cent | 0.02 |
| Cold test, °F | +10 |
| Aniline point, °F | 180 |
| Universal viscosity at 150 F sec | 38.1 |
| Characterization factor | 12.20 |
| 100 ml distillation | |
| IBP, °F | 430 |
| 10 per cent | 494 |
| 30 per cent | 536 |
| 50 per cent | 563 |
| 70 per cent | 591 |
| 90 per cent | 624 |
| Yields, per cent of cracking unit charge | |
| Ethane and lighter hydrocarbons, cu ft/bbl of charge | 183 |
| Propylene, liq. vol. per cent | 8.7 |
| Propane, liq. vol. per cent | 2.4 |
| Butylene, liq. vol. per cent | 9.6 |
| Butanes, liq. vol. per cent | 8.2 |
| 400 F EP gasoline, vol. per cent | |
| Debutanized basis | 68.6 |
| 10-lb RVP basis | 723 |
| Cycle stock, vol. per cent | 10.0 |
| Coke, wt. per cent | 6.0 |
| 10-lb RVP polymer gasoline, vol. per cent | 12.1 |
| Total 10-lb RVP gasoline, vol. per cent | 84.4 |

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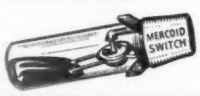


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ity of 35 and a boiling range of 460-630 F. This observation that there is little loss in API gravity and little change in boiling range when a Pennsylvania gas oil is catalytically cracked, even at high conversion level, is explained by the fact that Pennsylvania gas oil contains about 95 per cent paraffin hydrocarbons and when it is cracked catalytically, the paraffin content of the cycle stock is still high. In the case of a Mid-Continent gas oil, which contains perhaps 30 per cent naphthenes and aromatics, the cycle stock from catalytic cracking is much more refractory and contains a higher concentration of aromatics, which do not burn as well as paraffins in pot-type burners. For example, a 32-deg API gravity Mid-Continent gas oil cracked at 90 per cent conversion and 2:1 recycle ratio would produce a 23.5-deg API cycle stock having a characterization factor of 10.9, which indicates a rather high aromatic-naphthene concentration.

Although the charge stock to the thermal cracking operation, summarized in Tables 6 and 7, was slightly lower in gravity than that used in the catalytic cracking tests, it is of interest to compare the properties of the fuel oils produced in the two cases. The fuel oil from thermal cracking had an API gravity of 11.1 and a Universal viscosity of 430 sec at 100 F, as compared with the 35-deg API, 36 SSU at 100 F viscosity catalytic cycle stock. It is apparent, therefore, that in addition to increasing overall octane number the catalytic cracking operation increases the distillate fuel yields obtainable from a barrel of Pennsylvania crude over that obtainable when thermal cracking is employed. By the addition of a small amount of kerosine or light gas oil to reduce the pour point from approximately 20 F to an acceptable value and to lower the 10 per cent point to 440 F, the catalytically cracked Pennsylvania cycle stock will meet No. 2 distillation fuel specifications, whereas the thermally cracked residuum, which is produced largely by polymerization reactions at high pressure, can only be sold as No. 6 fuel.

Recent laboratory diesel engine tests have been conducted on a light Pennsylvania catalytic cycle stock produced at approximately 50 per cent conversion as shown in Table 10. The GM 3-71 diesel engine was operated on four different fuels at high output for comparison. Although the samples of fuel varied in gravity, sulphur content and cetane number to a marked degree, there is no appreciable difference between the fuels so far as their effect on engine operation is concerned. It is apparent from the data that the Pennsylvania catalytic cycle stock is, in nearly all instances, as good as or better than any of the other three fuels tested.

**TABLE 9. UOP fluid catalytic cracking Pennsylvania gas oil. Properties of products.**

| | |
|---|---|
| Composition of ethane and lighter hydrocarbons, mol. per cent | |
| Hydrogen | 37 |
| Methane | 33 |
| Ethylene | 12 |
| Ethane | 18 |
| Total | 100 |
| Debutanized 400° F EP gasoline | |
| Gravity, °API | 59.0 |
| Total sulphur, wt. per cent | 0.01 |
| Mercaptan sulphur, wt. per cent | 0.001 |
| Reid vapor pressure, lb | 6 |
| Octane numbers | |
| F-2 Motor clear | 79.0 |
| +3.0 cc TEL/gal | 85.0 |
| F-1 Research clear | 87.5 |
| +3.0 cc TEL/gal | 94.5 |
| 100 ml distillation | |
| IBP, °F | 110 |
| 10 per cent | 139 |
| 30 per cent | 173 |
| 50 per cent | 222 |
| 70 per cent | 286 |
| 90 per cent | 382 |
| EP, °F | 408 |
| Cycle stock | |
| Gravity, °API | 35.0 |
| Universal viscosity at 100 °F sec | 36 |
| 100 ml distillation | |
| IBP, °F | 462 |
| 10 per cent | 480 |
| 30 per cent | 490 |
| 50 per cent | 504 |
| 70 per cent | 521 |
| 90 per cent | 580 |
| EP, °F | 630 |

● **Summary.** The preceding discussions may be summarized by referring to Figs. 4 and 5. These flow diagrams compare the results obtainable by processing 5000 bbl per day of Pennsylvania crude in both "present operations," which include thermal reforming and cracking, and in

**TABLE 10. Comparative results of laboratory GM 3-71 diesel engine tests.**

| | Wyoming catalytic cycle stock | Pennsylvania catalytic cycle stock | California straight run gas oil | Mid-Continent straight run gas oil |
|---|---|---|---|---|
| Properties of fuel tested | | | | |
| Gravity, °API | 26.9 | 38.2 | 33.1 | 31.7 |
| Total sulphur, weight per cent | 1.19 | 0.07 | 1.28 | 0.66 |
| Cetane number | 33 | 60 | 42 | 35 |
| 100 ml distillation | | | | |
| IBP | 340 | 395 | 385 | 394 |
| 10 per cent | 469 | 460 | 432 | 429 |
| 50 per cent | 518 | 510 | 511 | 514 |
| 90 per cent | 597 | 585 | 600 | 607 |
| EP, °F | 652 | 630 | 678 | 646 |
| Results of tests | | | | |
| Total deposits, grams | 14.76 | 5.24 | 13.10 | 9.36 |
| Visual rating*, avg | 7.5 | 7.6 | 7.3 | 7.8 |
| Top ring wear | | | | |
| Gap, micro in./hr | 80 | 32 | 41 | 70 |
| Weight loss, mg/hr | 2.2 | 0.7 | 1.3 | 2.3 |
| Lube oil inspection | | | | |
| Neut. number | 0.63 | 0.96 | 0.64 | 0.79 |
| Sulphur, per cent | 1.47 | 1.49 | 1.28 | 1.24 |
| Dilution, per cent | None | 0.4 | None | 0.4 |
| Conradson carbon, per cent | 0.65 | 0.78 | 0.61 | 0.95 |

*10=clear. 0=dirty.

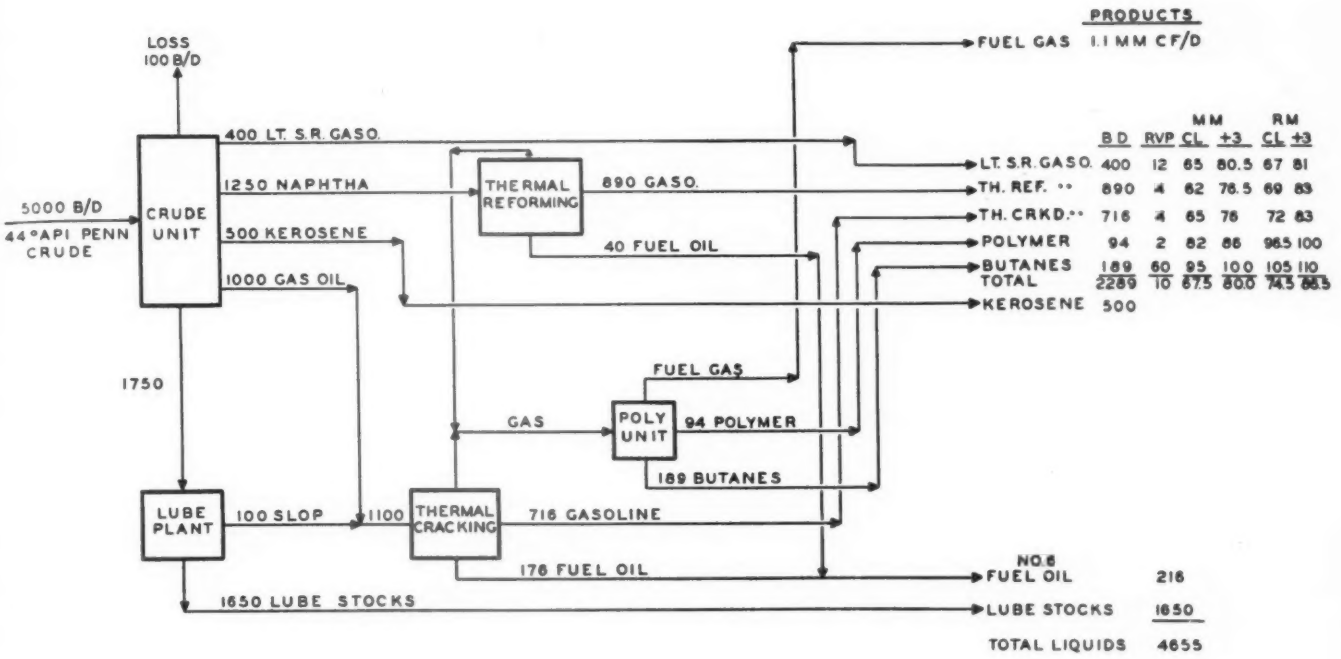


**FIG. 4. Present operations with thermal cracking and thermal reforming.**

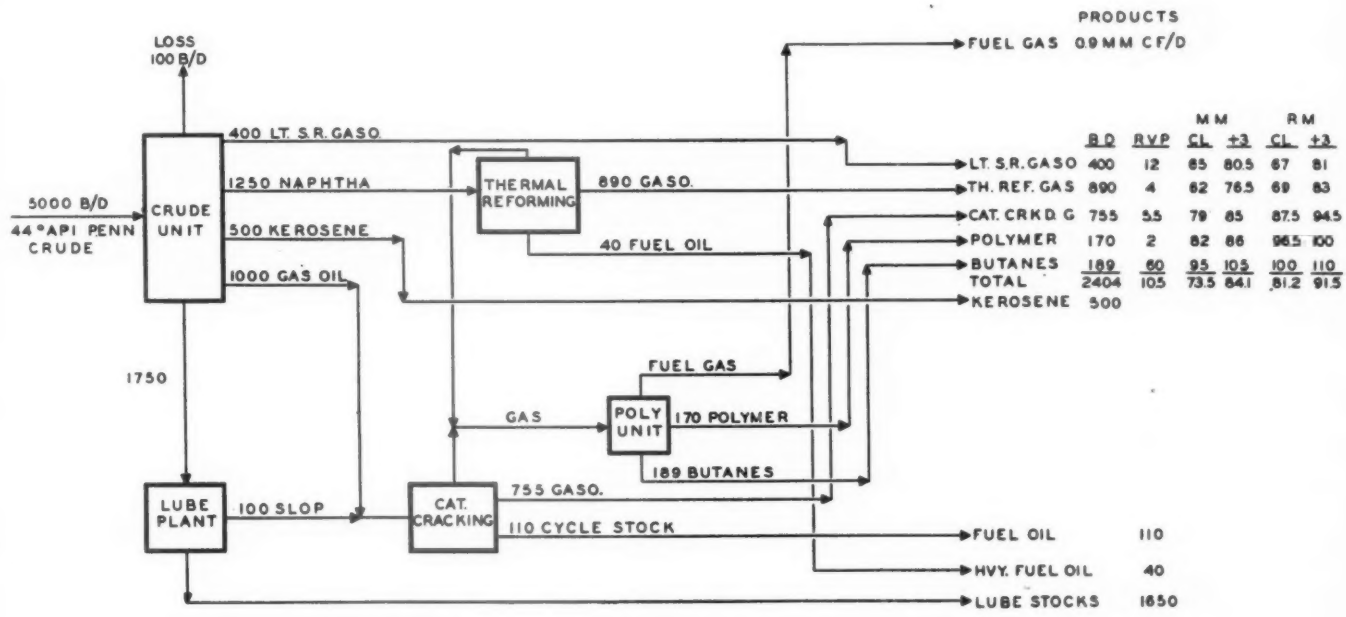


**FIG. 5. Refinery operations with fluid catalytic cracking and thermal reforming.**

a scheme in which the thermal cracking operation is replaced by fluid catalytic cracking.

As indicated in Fig. 4, the crude oil is fractionated to produce 400 bbl per day of light straight run gasoline, 1250 bbl per day of 24-octane naphtha, 500 bbl per day of kerosine, and 1000 bbl per day of gas oil cracking stock. The remaining topped crude is charged to a lube oil plant. It was assumed in this example that the naphtha would be reformed to 62 Motor Method octane on a debutanized basis, and that the gases from reforming and cracking would be polymerized to a degree corresponding to the production of a total gasoline blend having a Reid vapor pressure of 10 lb. The thermal cracking yields have been adjusted to conform with the present commercial practice of undercutting the gasoline end point to about 370 F.

In Fig. 5 the crude distillation and reforming yields are the same as in "present operation" and the 1100 bbl per day of gas oil plus lube plant slop is charged to the catalytic cracking unit. The yields used are the same as those listed in Table 8. In this scheme, however, it is possible to polymerize all the available propylene and butylenes without encountering a vapor pressure deficiency. These comparisons show that it is possible to increase the overall gasoline yields by 115 bbl per day, or by about 5 per cent, and its leaded Motor Method octane rating by 4.1 points when catalytic cracking is substituted for thermal cracking. In addition, the overall liquid recovery is increased slightly and 110 bbl per day of light distillate fuel is produced at the expense of No. 6 fuel production.

It might be mentioned that if it is desired to produce an overall gasoline blend in the catalytic cracking scheme, which has the same Motor Method octane rating as that obtained in the "present operation," the reforming conversion could be decreased to a point corresponding to a reformed debutanized gasoline yield of about 85 per cent. This would result in the production of about 2500 bbl per day of total gasoline or an increase of about 200 bbl per day (8 per cent) in gasoline production as compared with "present operations." ★★★

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# BLUEPRINT FOR RADIO

By DOUGLAS F. BALL

Communications Engineer, Motorola Inc.

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FM, or frequency modulated, radio had been developed for some time, and its many virtues had been enumerated many times by Major Armstrong and other advocates, but it took the Signal Corps, the infantry, the air forces, and the Navy to take this new weapon into field and prove its worth.

That same radio is with us today. There have been improvements, of course. Communications radio is now ready to take up the burden of supplying communications to the thousands of industries who can make use of it in the expansion of their communications systems.

To those industries who already have extensive wire and cable facilities it presents a challenge. In many cases it can entirely supplant wire facilities, and in all cases it can provide an emergency service of untold value.

In everyday use it can perform efficiently many functions. It can be used in its many variations for voice, telegraph, printer, facsimile, telemetering, seismic exploration, relay, remote control, and numerous other applications. These applications are vital to the oil industry. As we have a vital and important tool, an important factor is its proper use. In manufacturing, industry, and elsewhere, when a new product or a new tool is developed a set of blue prints and instructions for proper use of that tool accompanies it. Without these blue prints and instructions the tool could be ruined, or unsatisfactory results obtained. In the following paragraphs, we will attempt to establish a blue print of sorts, and include a few simple instructions for the use of two-way radio. We will mention briefly some of the factors that cause improper functioning of the equipment on an overall basis, and how to avoid them.

● **Wave propagation.** There are numerous books on the subject of wave propagation, and thousands of articles written by scientists and engineers, all of which are good. By consulting them one can obtain a good picture of what happens to radio waves when they leave the antenna and begin their journey into space. The principal consideration is what we can do to see that the waves propagated from our transmitting antenna get to their desired destination with a maximum signal strength and a minimum of interference.

● **Antennas.** There are numerous types of antennas developed for specific applications. The antenna to use is the one that will most nearly give the results desired. The angle of radiation is important, and the waves of most importance to us are those that are propagated on a plane horizontal to the earth. All antennas dissipate some energy in directions that are not useful to us, and that same energy may be reflected back or downward from the stratosphere to cause us or other users of the same wave length untold interference. This phenomenon is sometimes called a "skip," and at times is very troublesome; however, under certain conditions this same phenomenon may be taken advantage of to obtain communications over long distances. As we desire to obtain transmission over a medium range with a minimum of loss, we must have an antenna that will do the following:

1. Maintain a low angle of radiation;
2. Present the proper impedance match to the transmission line or cable, and hold the standing wave ratio to a minimum;
3. Prevent energy from being dissipated on the transmission line and support structure;
4. One that is cut or capable of being tuned to the frequency band being used;
5. Reduce noise pickup to a minimum.

For fixed station to mobile operation, it is always desirable to use an antenna that is omni-directional, that is to say, one that transmits equally well in all directions. For point-to-point operations certain types of directional antennas can be used to advantage. Antennas of the directional type, with the proper selection of directors and reflectors may be used to obtain an apparent increase in power output in a given direction. Actually what happens is that by the use of the directors and reflectors more of the power is concentrated at a low angle of radiation and directed or aimed toward a certain point.

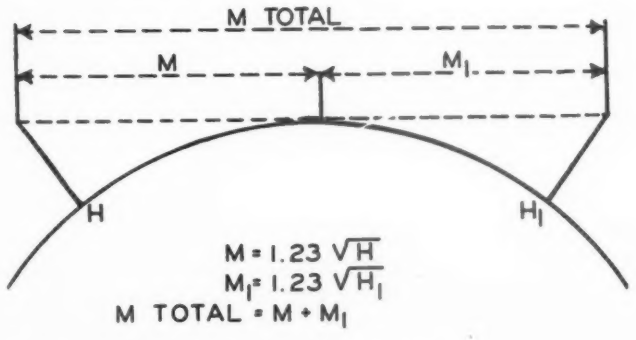
For repeater operation, two antennas of the uni-directional type may be placed back-to-back and connected in parallel to obtain a bi-directional array with increased efficiency; however, care must be exercised here to see that the proper load impedance to the transmitter is maintained.

● **Antenna height.** As we are interested in the wave lengths ranging from very high frequency upward through the ultra high frequencies, we say that the wave propagation is line-of-sight for the most part. In other words, there is very little bending around the earth's surface.

The curvature of the earth being considerable (approximately 8 in. to the mile), it can be seen readily that to transmit from one point to another point on the earth's surface, one or both points must be elevated. Another factor to consider is whether the earth's surface between the two points is level or whether there are obstructions such as hills, mountains, or tall structures. If the surface is irregular, or is covered with trees, this factor must also be considered in determining the proper antenna heights at either end.

A suitable formula for determining antenna heights is $M = 1.23\sqrt{H}$, for one tower, and $M_1 = 1.23\sqrt{H_1}$ for the second tower, then, $M + M_1$ = total distance that can be covered over smooth terrain with a given antenna height. (See sketch) If there is intervening hilly country the overall height of the hills above the average must be added to one or both towers for line-of-sight transmission over the obstruction.

Towers should be placed, if possible, where there will be no abrupt changes in the earth's contour within the dis-




**Sketch for line-of-sight**

tance of one-half mile from the transmitting tower. This is very important, and may explain why some apparently excellent antenna sites have not given the desired results, or have shown a decided directional effect, or perhaps dead spots in other directions. In general, the antenna site should be on the highest available point, but with a gradual slope away from the tower in all directions.

Probably some will say that the above formula may be all right, but there are known conditions wherein twice the indicated transmission range is being covered. This is no doubt true at times, but perhaps not during the entire year, or perhaps not even over a 24-hr period. For a radio system to fulfill the requirements of good communications, it must be capable of giving service at *all* times and under *all* conditions of seasonal and atmospheric variations. To be capable of this, the system must be so designed that ample power will be available at the receiving antenna under all conditions.

Noise level is very important at receiving locations. When the transmitting antenna is used also as a receiving antenna, careful consideration must be given to the noise at this point also. When the noise level is high it means that sufficient signal strength must be available to override the noise with enough reserve to give full quieting of the receiver at all times. If the noise level is high at the best antenna location from a transmitting standpoint, it is sometimes advisable to place a separate receiving antenna at some other point and connect to the central control point by wire line or cable. If a compromise is indicated between the best transmitting location and a point where the noise level is low, the decision should be in favor of the point of lowest noise.

Receiver noise components may be a product of many different types of noise. Some of these may be eliminated if traced to their source. Some of the noises may come from overloaded power transformers, defective insulators, poor grounds, arc, rotating machinery, fluorescent lights, neon signs, medical therapy machines, X-ray machines, industrial heat treating equipment, and a host of other sources. Most of these can be eliminated if a careful survey is made and filters of the proper type installed.

There are other sources of interference, such as atmospheric, sun spots, etc., for which there is no sure cure. Another source of interference is that from other radio equipment—both receiving and transmitting, or a combination of the two. This type of noise is by far the most difficult to localize in that it may arise from intermodulation frequencies from two or more transmitters remote from the receiver.

This problem is becoming more prevalent as the number of stations increases, particularly in congested city areas where good antenna locations are at a premium. Unless particular care is taken, it is inadvisable to install more than one antenna on the same roof, or even on adjacent buildings where the receiving antenna is subject to direct interference. Even though the frequency may differ by several megacycles, the receiver may be desensitized due to the large amount of RF voltage developed across the grid of the RF tubes in the receiver.

There are several methods of combating interference of the above types. If the trouble arises from spurious radiation, it is often possible to construct a filter from shorted lengths of transmission cable (copper cable is preferred due to its higher Q, but in some cases solid dielectric cable may be used).

For the higher frequencies, 152-162 mc, recent developments have included a cavity type filter. This unit is very effective in the reduction of undesirable interference at the receiver. It also can be used under certain conditions to permit the operation of more than one transmitter over a single antenna system.

This is a very brief account of some of the troubles that you may have experienced, and a few remedial measures to try. In the event of serious interference, all possible information should be obtained before any action is taken. Usually both parties can work out their problems on a mutual basis without resorting to interference complaints to the FCC.

In conclusion, although only a few of the many types of interference have been dealt with, it is hoped that this brief discussion will open the way for a better understanding of some of the principles involved in constructing and operating a satisfactory radio system. ★ ★ ★

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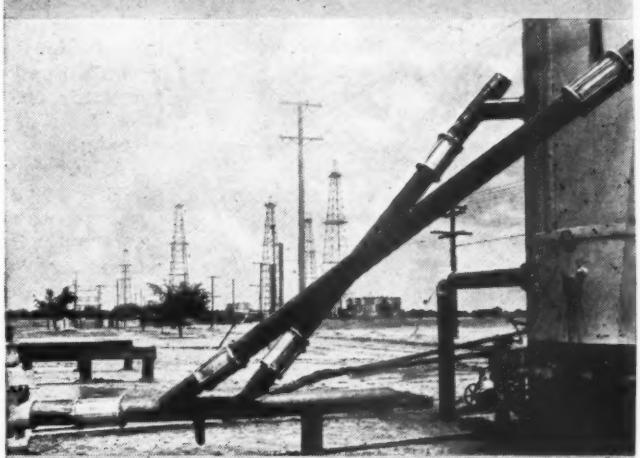

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# Sampling of crude oil

By ALLISON C. DYER
Oil Weigh Meter Company

THE sampling of crude oil would be a comparatively simple process if the oil itself were an uncontaminated, homogeneous fluid, or, conceding its lack of homogeneity, if it were possible to keep the components in intimate and stable admixture during the sampling period. Anyone who knows crude oil and its eccentricities will at once recognize the fact, however, that only rarely do either of these conditions prevail. It thus becomes necessary to set up some sort of system of sampling that will take care of a wide range of conditions, varying from the most irregular mixtures of oil and water, through all proportions of oil, water, and emulsion, to complete emulsification.

EXCLUSIVE

Regardless of the character of the parcel to be sampled, or the fluctuating relationship between its components, the objective of the process may be somewhat simply stated, as follows: A sample is a part of the whole, and must simultaneously display these characteristics in the same relationship to each other as they display in the complete body of fluid. The sample should not be so large as to present difficulties in handling, and should not be so small as to render the determination of its significant qualities difficult or uncertain. It has been the experience of the writer that under most normal conditions, the minimum volume ratio of sample to total fluid should be approximately 1 part to 6300, or about 2 gal for every 300 bbl. Under exaggerated conditions, of course, that is when there is extreme heading or the fluid contains an abnormally high content of free water or loose emulsion, it becomes imperative to increase the size of the sample.

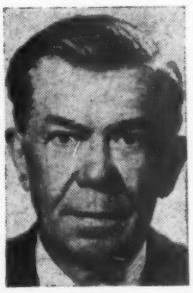
Discussing now the various methods of crude oil sampling, it will be readily acknowledged that the lead line method, as commonly practiced, is something of a makeshift at best. It is particularly inaccurate in the case of a well that is flowing by heads, and although the error may be cut to some indeterminate extent by sampling at the estimated middle of the head or by taking small samples at frequent intervals, there is no assurance that in such instances the part is representative of the whole. When the well is clean and dry, or when the water content is emulsified and evenly distributed, a grab sample from the lead line may be reasonably accurate, but such conditions are rare, and basically the method is unreliable anyway, because although conditions at the moment may be conducive to accurate sampling, there are a variety of agencies and influences that can, and frequently do, cause existing conditions to change quickly and markedly.

There are a number of ways in which oil may be sampled in tanks. One of the oldest and most often used is the three-point method, the popularity of which is largely attributable to its convenience. The customary application of this method first requires that the gauger run off through the bleed valve all free water. From that part of the tank content lying above the bleed valve there are then taken three equal quantities of oil, one each from the top, middle, and bottom. These are mixed to constitute a representative sample of the whole. The accuracy of this method is again dependent on the homogeneity of the fluid, and the fluid even after the free water has been bled off may be far from homogeneous. The tendency is for the lighter fractions to float at the top, while the heavier components settle in irregular stratification nearer the bottom. This renders the three-point method somewhat precarious. In fairness, however, it may be said that for dry clean oils it is quite accurate, but when emulsion and water are present the distribution of these through the body of the oil may not necessarily be uniform, and when this is true sampling by the three-point method may be in extreme error.

The bottle thief, as the name implies, is a bottle shaped copper vessel with a weighted bottom, which is lowered through the oil to the desired level. Some operators specify that the thief shall be lowered to the proper level, and raised again to the surface at a uniform rate, controlled so that a small quantity of oil is captured at all levels, in other words, that the device is sampling continuously. For this reason, the gauger speaks of his bottle thief as a "running sampler." Other operators insist on corking the thief, lowering it to the requisite level, and then raising it with the cork removed by means of some tripping device. The thief must reach the surface before it is quite full, otherwise there is no way of knowing at what level it became full. It is quite obvious, however, that in such an instance it has not sampled at all levels, and that part of the vertical section has been missed. Regardless of what variation of the bottle thief method is used, it is presumed that the same quantity flows into the bottle at all levels, regardless of hydrostatic pressure and the changing viscosity of the various strata. Here again it is patent that the method can be accurate only for clean dry oil, and that when the oil is wet or emulsified, its efficacy is subject to doubt.

An improvement over the methods so far mentioned for the sampling of wet or emulsified oil is a tubular thief that consists essentially of one tube that turns sufficiently within an outer tube of larger diameter to permit concentric ports to be brought together or closed off from

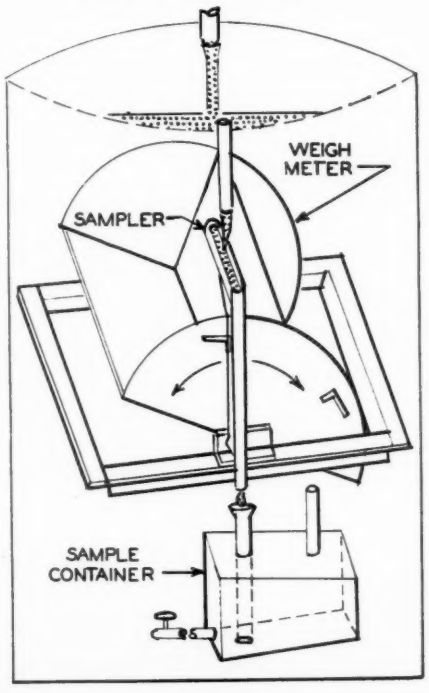
**THE AUTHOR**



Allison C. Dyer

Allison C. Dyer first became an oil worker at Poso Creek, California, in 1923, when he was employed as a rotary helper by Chanslor Canfield Midway Oil Company. In 1927 he was appointed assistant petroleum engineer for the USGS at Taft, California. In 1929, he and his brother, Hayward, began an association with their father, a mining engineer. This grew into the Oil Weigh Meter Company, of which the brothers are now co-owners. Allison holds the position of chief engineer. They are also the joint inventors of the meter from which the firm takes its name.

**Detail of sampler, which takes cross section of each dump at sufficiently frequent intervals to provide representative samples of oils containing free water or loose emulsion.**



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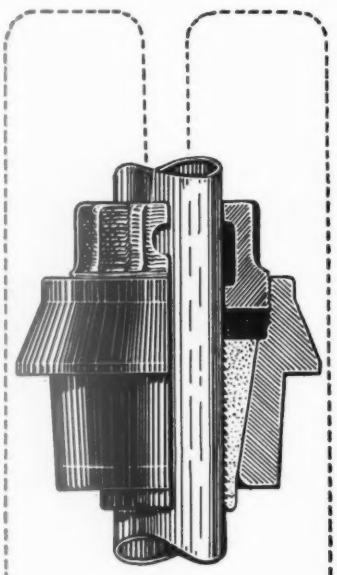

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each other at will. Each tube is drilled with holes spaced about 1 in. apart. The holes are then brought into operation and the tube is allowed to fill. They are then closed and the contents of the tube are run off into the sample container through a valve in the lower end. This instrument is, of course, inaccurate when stratification of emulsion is irregular, or the water-oil interface does not lie in a horizontal plane, not uncommon situations. In fact, sometimes a species of billowing takes place that throws the strata off horizontal to a startling degree. If a number of such tubular thieves could be installed at various points in the tank and used simultaneously the composite sample would be more representative.

A variation of the foregoing method is to be found in the spot core thief, which may be anywhere from a foot to three feet long. It, too, is a tubular device with side ports or a bottom opening that can be controlled by the use of a trigger with a string attached. For a full core sample this instrument is lowered, open, on a gauge tape to the required level, and is then closed and brought to the surface again. Beginning at the top, successive samples are taken at continuous lower levels until a full core has been taken. From the description it is obvious that care must be exercised on each trip to make sure that the thief is sampling the right section. It will also be obvious that there is a decided tendency to roil up the successive strata and alter their original status, or relationship to each other. In addition to that this thief is somewhat messy to handle, and is subject to the same errors as the fixed core sampler in heterogeneous fluids, even when manipulated with the maximum of care and precision.

Long study of the many factors involved in the sampling of crude oil, particularly for well accounting, has led to the development by this writer of a unique type of lead line sampler, which takes, as nearly as it is possible to do so, a true cross-section of the line flow, and this with sufficient frequency to provide a representative portion of the total fluid. This device is used in conjunction with a weigh meter, and consists of an adjustable rectangular orifice that passes periodically through a freely falling line flow, the frequency of the passage being determined by the rate of incoming flow. The orifice is adjusted to meet the minimum requirements as indicated earlier in this discussion, and the sample so obtained is bypassed to a container within the meter case.

This inner mounting is important in that it prevents a thermal or pressure differential between the acquired sample and the stream from which it is taken. The resultant gravities of the samples and the main bodies must then be in agreement. The container itself is so constructed that it has no moving parts, and being fully protected can retain the sample unaltered even when it is left inside the meter for considerable lengths of time. As mentioned in the preceding paragraph, the sampler consists of a rectangular box with the bottom sloping toward the outlet. Its top, through which two ¾-in. pipes are inserted, is closed. The pipe that receives the sample protrudes about an inch above the upper surface, and extends to within ⅜ in. off bottom. The so-called riser pipe at the other end of the box is cut off flush with the inside top but rises about 4 in. above it on the outside.

As the oil and water enter the container the water gravitates to the bottom, and when the full capacity of the container is approached, the oil enters the riser pipe. When a hydrostatic equilibrium is reached between the fluid column in the inlet pipe and that in the riser, there can be no further ingress of fluid. It may be readily seen that at this time there is a water seal around the bottom of the inlet pipe that prevents any replacement of oil by water.

When the water content of a crude oil sample is unduly high, we have found that settlement takes place so fast in many instances that it is not practical to attempt to shake the sample into any semblance of uniformity, and then test a small portion for water. For samples taken by the method just described in conjunction with a weigh meter, we use a carefully calibrated tube with a bottom drain valve. This is filled with sample, and after standing for a short time the free water is noted and bled off. The process is repeated until all the sample has been exhausted, and all the free water has been recorded and removed. To the oil remaining in the tube some Tretolite is then added, and again the free water is noted and removed after a reasonable period of settling. The final step in the process is to shake up the remaining sample thoroughly, and subject a proportionate quantity to the centrifuge test, or if possible centrifuge the entire remaining sample. In either case it is then a simple matter to determine the water percentage from the total accumulation and the original total volume of fluid.

The special lead line sampling method discussed in detail here has been used in many producing areas and without regard to the character of the fluid. It has proved a valuable aid not only in arriving at the net yield of individual wells, but in the more complex proration of gross and net production of groups of wells back to the individual producers. There are limitless applications of the device and, indeed, it would seem that wherever and whenever it is necessary to obtain a representative sample of a heterogeneous fluid, it would be well worthy of consideration. If it can be depended upon to handle oil flows containing loose emulsions, rapidly settling free water, or irregular quantities of two or more liquid constituents, it is a fair assumption that it will also and with even greater accuracy handle other well flows that are even more homogeneous in character. ★ ★ ★

# The dielectric properties of oil sands

By ROBERT THORN WHEELER

**THE AUTHOR**

The thesis, "Dielectric Properties of Oil Sands," was prepared by Robert T. Wheeler for his engineering degree at Stanford University, California. He received his degree in April of this year.

Previous to this, Wheeler graduated in 1943 in engineering chemistry, and received his M.S. in petroleum engineering in 1947, at Stanford. The three years from 1943 to 1946 were spent as an engineering officer on destroyer escorts in the U. S. Navy. He has been with the field research department of Union Oil Company since January, 1948.

● **Introduction.** The dielectric properties with which this paper deals are the dielectric constant, and the dissipation factor. Other important properties are the dielectric loss, the loss factor, the power factor, the a-c and d-c conductivity, and the electrical breakdown strength.

EXCLUSIVE

Dielectric constant, or specific inductive capacity, is a measure of the ability to store electrical charges. Air or vacuum has a dielectric constant of 1, and pure water a dielectric constant of 78. This property can be defined as the ratio of the capacitance of a cell containing a substance to the capacitance of a cell containing air or another material of known dielectric constant.

$$K = C_1/C_0$$

The dielectric constant will be referred to as K throughout this paper.

It is now generally known that the dielectric constant of substances containing polar molecules is not a constant, but varies with the frequency and the temperature. In the work covered in this paper, the temperature variation was eliminated by making all runs at 77 F.

A dielectric substance has an energy loss when an alternating voltage is applied. This energy loss can be expressed in several different ways: Power factor equals the cos Θ; dissipation factor, $D = \cot \Theta = R/X$, where Θ=the phase angle, R = the resistance, and X = the reactance. Loss factor is the energy loss per cycle per squared voltage gradient per unit volume. In this paper dissipation factor was used as a measure of the energy loss.

The general curve of the loss-factor and the curve resulting when the dissipation factor of a material is plotted against the frequency, show that the curves are identical except that they are displaced from one another. The loss-factor curve, reaching a maximum first, is equal to one-half the change in dielectric constant.

$$\text{loss factor} = \frac{K_o - K\alpha}{2}$$

The maximum, therefore, occurs when one-half the change in dielectric has taken place. The frequency at this point is called the relaxation frequency. It is defined as the time required for the polarization to come to the quantity, 1/dielectric constant, short of completion.

When the dielectric constant of a substance is measured in the range from one-millionth of a cycle to the frequency of light, certain decided dips in the curve occur at various frequencies, the first being at approximately 100 microcycles. This lowering of the dielectric constant generally occurs first where the interfacial oscillation of the particles ceases to be of importance. In other words, at low frequencies polar molecules, that is, molecules with the centers of their positive and negative charge displaced by a small distance, oscillate in the alternating field. As the frequency is increased, the distances travelled become smaller until they have no effect. The maximum energy loss should, therefore, be at the lower frequencies. As the frequency is low, however, the maximum loss-factor occurs at some intermediate frequency. This was shown by the above formula. The loss in a substance shows up as heat, and is the direct result of the friction of the particles bumping each other in their movement. The next drop in the curve is where the polar molecules can no longer completely rotate. At low frequencies, the rotation is complete in one cycle, and maximum contribution is given to the dielectric constant. There are several other drops in the dielectric constant curve, which are due to molecular and atomic rotations, but they occur mainly at very high frequencies. The magnitude of these losses can be found by taking the index of refraction of light waves in the dielectric. The dielectric constant at the frequency of light is equal to the index of refraction.

A good dielectric, such as quartz, polystyrene, or solutions containing nonpolar molecules, have almost the same dielectric constant from the lower to the higher frequencies.

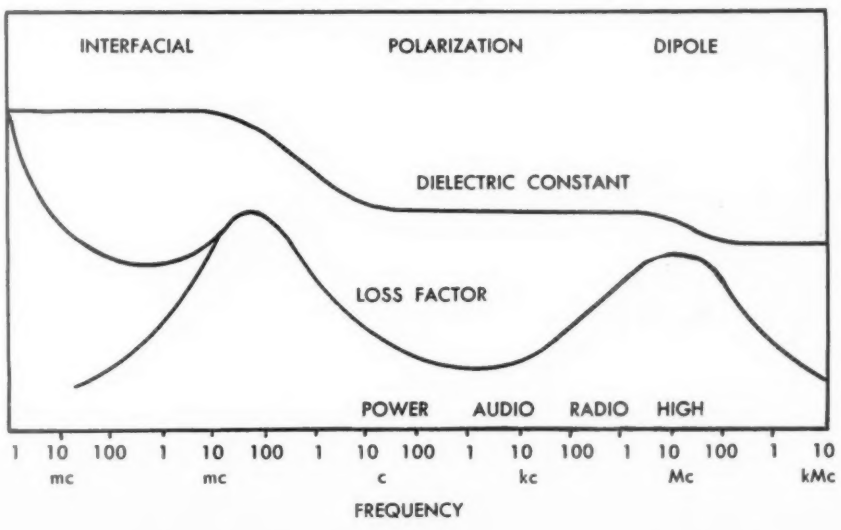
There has been very little information published on the dielectric properties of substances, and no data have been found on the subject presented here. The most valuable source of information on dielectric properties was an unpublished paper written by R. F. Field of General Radio Company.

● **Objective.** The object of this research was to determine the dielectric properties of various types of oil sands at radio frequencies. The work accomplished is just the beginning of a project that requires a considerable amount of equipment and time. It is hoped that, eventually, the dielectric properties of actual core samples will be determined.

It was first decided to test the dielec-

**FIG. 1**

*From: The Behavior of Dielectrics Over Wide Ranges of Frequency, Temperature and Humidity; Field, R.F., General Radio Company (unpublished).*



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•

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tric properties of synthetic oil sands. By this method, the factors that contributed most to increasing the dielectric constant could be controlled and noted.

Dielectric properties, namely the dielectric constant and the dissipation-factor, were determined for these synthetic oil sands at frequencies between 1 and 30 megacycles, and at a temperature of 77 F.

The various runs made were: Dry sand, sands containing up to 20 per cent of the pore volume filled with a suitable connate water, pure kerosine, and sands containing 20, 40, 60, 80, and 100 per cent of the pore volume filled with kerosine.

It was found that the salt water was the chief factor in raising the dielectric constant. Both dissipation-factor and dielectric constant decrease rapidly from 1 megacycle.

The reason the work was undertaken to determine the dielectric properties of oil sand was to provide a theoretical basis for further research in the field of secondary recovery methods as applied to increased production in oil fields.

● **Equipment.** The equipment used for the measurement of the dielectric constant in this thesis is similar to that used in the hetrodyne beat method. A signal is put through a bridge, and a radio receiver is used as a detector. When the bridge is in balance, no signal is heard from the receiver. A schematic wiring diagram of this apparatus is shown in Fig. 2.

The signal was produced by a model E-200 series, Precision signal generator. The frequency of the transmitter ranged from 50 kilocycles to 30 megacycles on fundamental frequencies, and from 30 megacycles to 120 megacycles on harmonics. Instead of using the unmodulated note as in the hetrodyne beat method, a 400-cycle modulated note was used. Both methods were checked, resulting in the same accuracy, and as it was easier to hear the null points using the 400 cycle note, that method was used through-

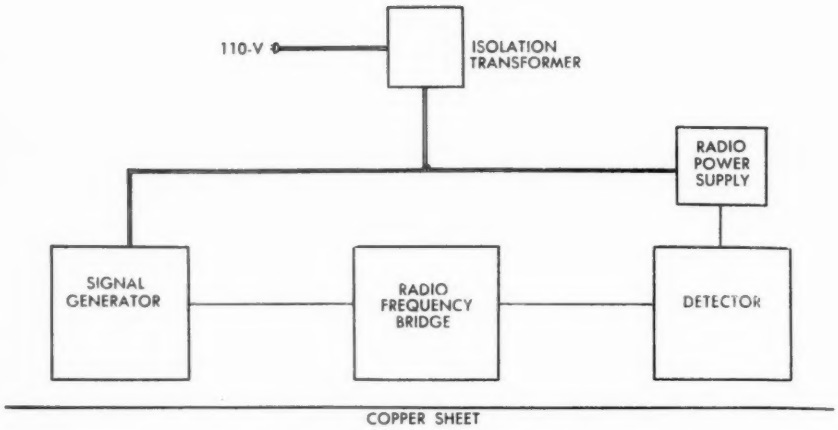



**FIG. 2. Schematic wiring diagram.**

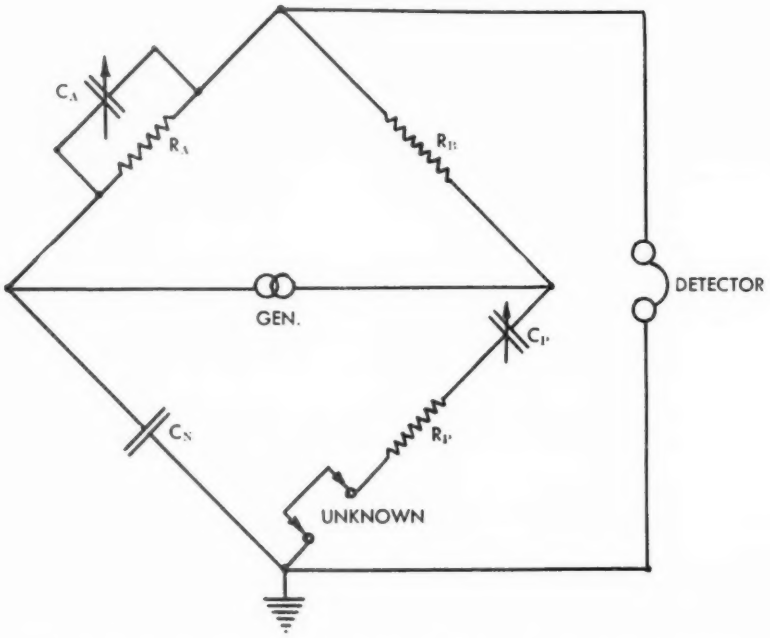



**FIG. 3. Basic circuit diagram of type 916-A radio frequency bridge.**

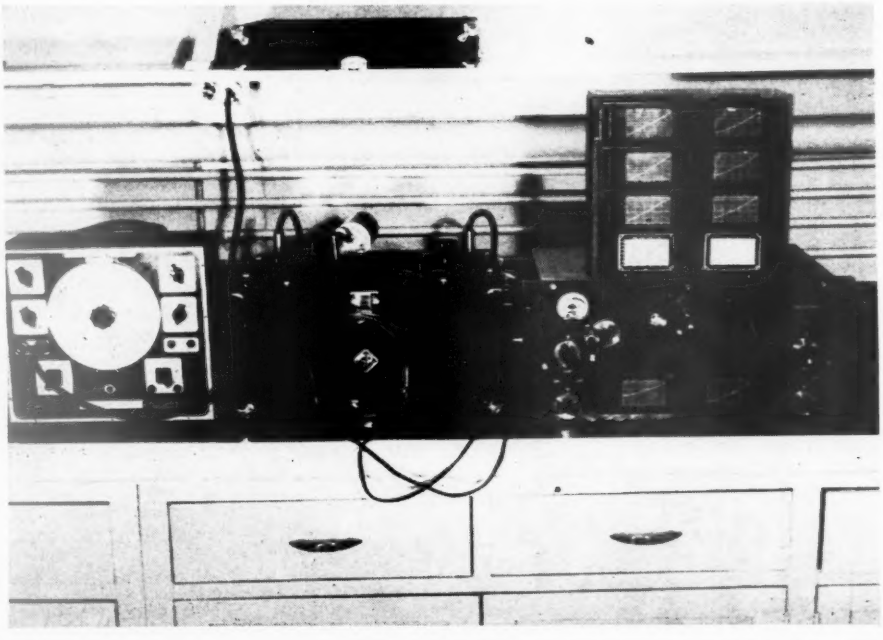
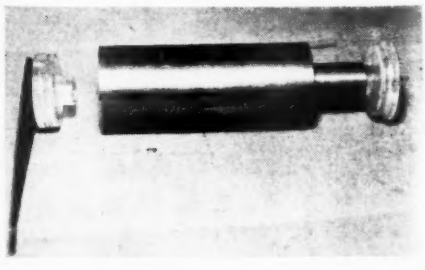


**FIG. 4.**

**Left, view of apparatus used in making determination of dielectric constant.**

**Below, dielectric constant cell used for holding unconsolidated oil sand.**



# Baash-Ross News

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OUR 28th YEAR

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## BAASH-ROSS "DU" ROTARY SLIPS ARE UNUSUALLY LIGHT WEIGHT

**. . . and Light Weight is only ONE of *many* "DU" advantages!**

Stop and think how many dozens of times the rotary slips are lifted by the drilling crew during a *single* round trip. Multiply this by repeated day-after-day, month-after-month operations and you can readily appreciate why light weight is such an important factor to look for in rotary slips. *And you really get light weight in Baash-Ross "DU" Rotary Slips!*

For example, check these figures on typical sizes of "DU" Slips . . .

| Size of "DU" Rotary Slips | "DU" Regular (12" long) | "DU" Long (16" long) |
|---|---|---|
| 4½" O.D. Slips with 4½" Liners | 137 lbs. | 158 lbs. |
| 5⅝" O.D. Slips with 5⅝" Liners | 146 lbs. | 177 lbs. |
| 7" O.D. Slips with 7" Liners | 154 lbs. | 196 lbs. |

On these and other sizes you'll find Baash-Ross "DU" Rotary Slips are pounds lighter because all excess metal has been removed without in any way sacrificing strength or ruggedness. *Notice the deeply-cored backs that replace dead metal with a cellular rib construction that combines more-than-ample strength with minimum weight.*

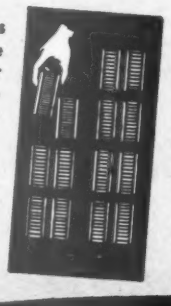
▶ **But most important** is the fact that unusually light weight is only *one* of many important advancements you get in Baash-Ross "DU" Rotary Slips. Carefully check through the features outlined below . . . compare them right down the line with *any other* make of slips . . . and you'll see why "DU" Rotary Slips are today's outstanding buy for maximum convenience, safety and all-around economy!

Baash-Ross "DU" Rotary Slips are available in both "Regular" length (12" long—for wells through 8000 ft. in depth) . . . and "Long" length (16" long—for the deepest wells and heaviest drill strings). For full details, see your nearest Baash-Ross representative—or write direct!

## WHAT OTHER SLIPS COMBINE SO MANY OUTSTANDING ADVANTAGES?

▶ **3 BODY SIZES FIT 14 PIPE SIZES:** With "DU" Slips you don't need a separate slip for each size of drill pipe. By simply changing the liners—a quick inexpensive operation—*three* basic "DU" body sizes fit *all* sizes of tubing, drill pipe and casing from 2⅜" O.D. through 7" O.D. Cuts slip investment and maintenance to a minimum!

▶ **MONEY-SAVING SEGMENTED LINERS:** "DU" Slip Liners are in 4" segments instead of single long units. If you use both 12" and 16" Slips there's no need to stock liners for both sizes. Simply keep a supply of 4" segments on hand—use three 4" segments for 12" Slips . . . four 4" segments for 16" Slips . . . thus greatly reducing inventory costs. Also, if for any reason slip wear is concentrated at one point, liner segments can be switched or inverted to distribute wear without replacing any parts. Or if too worn, replace only the worn segments and use the others for additional service. Cuts maintenance costs to the bone!



▶ **SELF-ALIGNING HINGE:** "DU" Body Segments are not merely hinged together, but are unitized by a unique "floating" hinge that prevents vertical misalignment, yet permits them to adjust laterally to any irregularities in bore of master bushing. This assures a full, uniform grip under all conditions!

▶ **SAFETY LINER RETENTION:** "DU" Slips are so designed that *all* stresses—both of supporting the pipe and of breaking out joints—are transmitted directly from the liners to the slip body. *There are no retaining bolts or pins to become sheared and allow liners to fall into hole.* Yet liner segments can be quickly removed by simply pulling a cotter and sliding out one keystone retaining key. This double keystone key firmly mates liners and body into single rigid unit!

▶ **AND OTHER ADVANTAGES:** There are still other vital "DU" advantages . . . the safety loops on the handles that safeguard crew's hands against injury . . . the polished backs that eliminate sticking in the bore . . . the perfected grip design that will not damage the pipe . . . the flattened toes that enable "DU" Slips to stand solidly on table or floor . . . and many other unique features.

BEFORE YOU BUY ANY ROTARY SLIPS GET THE COMPLETE STORY ON "DU" ALL-AROUND SUPERIORITY!

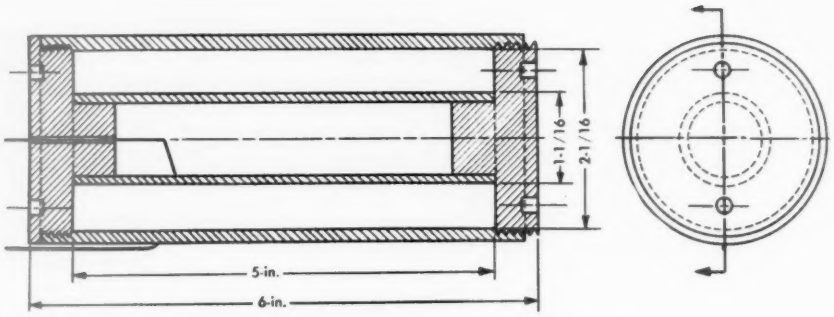



**FIG. 5. Dielectric constant cell full scale.**

out the tests. The output radio frequency voltage varied with changes in frequency from 0.2 to 1.5 volts.

The only change in the signal generator was to modify the radio frequency output connectors. The original connectors were removed and General Radio panel plug sockets were soldered in place. This alteration made it possible to use the coaxial cables that were supplied with the General Radio frequency bridge. This same addition was also made on the radio receiver, the center wire being attached to the antenna lead, and the shield being grounded on the chassis.

The bridge used in this setup was a General Radio frequency bridge, type 916-A. It has a frequency range from 400 kilocycles to 60 megacycles. Two transformers are required; the range of the first being from 400 kilocycles to 3 megacycles, and the other transformer covering the remaining frequencies. This is the Schering type of radio frequency bridge. A schematic diagram of this is shown in Fig. 3.

A National HRO Senior was employed as a detector. The coils shown in Fig. 4 covered the range from 1 to 30 megacycles. The power supply and speaker are not contained in the main chassis of the radio in order to eliminate hum.

This receiver has many advantages: Extreme sensitivity, a radio frequency gain, and audio output gain, an automatic volume control, and an "S" meter. The "S" meter was found to be extremely valuable in initially determining null points. In order to use the "S" meter, however, the automatic volume control had to be in operation. As it was thought that this might slightly change the frequency on which the receiver was tuned, the automatic volume control switch and "S" meter were turned off when the bridge was initially balanced. Also, a stronger signal was obtained when the automatic volume control was not in operation.

In hope of obtaining even further accuracy, both the radio frequency gain and the audio output were set at a maximum.

The volume was then controlled by shifting from the earphones to the loud speaker. A rough balance was made with the earphones plugged in, and a final balance was made with the loud speaker in operation.

The connection between the signal generator, the bridge, and the radio receiver were made with coaxial connectors.

Extreme caution was used in setting up the apparatus. All the above equipment was mounted on a large sheet of copper and carefully grounded. It is extremely important at high frequencies to have all the apparatus at the same electrical potential. The isolation transformer was inserted in the incoming power line to facilitate maintaining equal potential on all the different units.

The dielectric-constant cell was machined according to the specifications shown in Fig. 5. The size of the cell was determined before it was constructed. This is of the utmost importance because the bridge can only measure capacitances down to 30 micro-microfarads. Capacitances lower than this can be determined by taking readings with another capacitor in parallel. This, however, leads to more laborious calculations, and the chance of incurring slight errors.

The dielectric-constant cell body is made of copper, and the ends that hold the sand in place were machined from polystyrene.

There are several advantages in using concentric plates instead of a parallel plate condenser. The first being that the concentric cylinders can be more easily packed with unconsolidated sands. The second advantage is the size of the cell. Preliminary calculations showed that for a ½-in. thick sample, the plates would have a diameter of 6 in. The third advantage in using this design is to eliminate as much of the electrostatic end effects as possible. The longer the cell and the closer the plates, the less the end effects enter into the calculations.

● **Materials tested.** The eventual aim of this work is to measure the dielectric properties of actual core samples; however, it was decided to begin work with synthetic oil sands in order to control actual core size, particle distribution, and packing. A dry unconsolidated sand of certain particle size distribution was used so that when it was packed tightly it would more closely resemble sands found in actual formations. The sand used was crushed from a high quality quartz, resulting in very angular particles. The screen analysis of this sand is shown in Fig. 6.

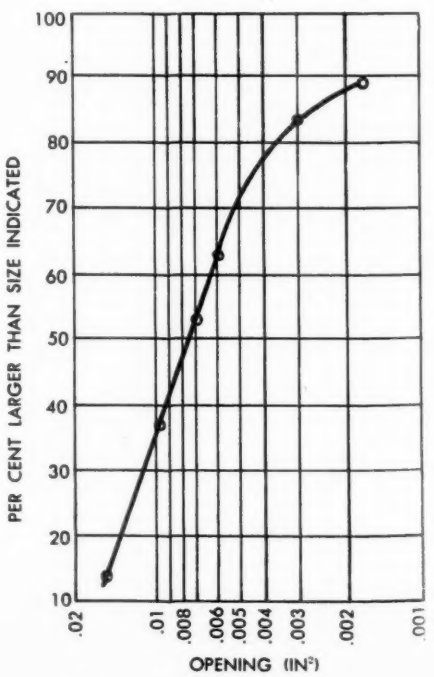
In actual formations, the pore volume of the cemented rocks averages about 20 per cent. The pore volume of the sand actually used in the determinations was 30 per cent.

The pore volume was determined by packing the sand in a stoppered graduate. Packing was accomplished by vibrating and tamping. The volume of the dry sand was recorded and a measured amount of kerosine was poured into the graduate containing the sand. At the end of a week, the kerosine had seeped thoroughly into the pore spaces and the volume of kerosine that remained was recorded. From this information, the pore volume was calculated.

As practically all oil sands contain some connate water, it was decided that runs should be made using only actual formation water. A synthetic connate water was made, similar to that found in

**FIG. 6. Cumulative logarithmic diagram of screen analysis on sample of quartz sand.**

| | *Mesh* | *Opening, in.* | *Sample wts.* | *Per cent* | *Cumulative per cent* |
|---|---|---|---|---|---|
| | 40 | 0.0150 | 26.80 | 13.45 | 13.45 |
| | 60 | 0.0097 | 46.20 | 23.15 | 36.60 |
| | 80 | 0.0069 | 32.35 | 16.20 | 52.80 |
| | 100 | 0.0058 | 20.00 | 10.01 | 62.81 |
| | 200 | 0.0029 | 40.30 | 20.30 | 83.11 |
| | 325 | 0.0017 | 11.70 | 5.87 | 88.98 |
| Pass | 325 | 0.0017 | 21.90 | 11.00 | |
| | | Total | 199.25 gr. | 99.98 | |



A DRILLING WELL SILHOUETTED AGAINST A TYPICAL EASTERN VENEZUELA SKY

SCHLUMBERGER is an "old hand" in Venezuela, having enjoyed close fellowship with Venezuelan oil operators since 1929. As a result of the unselfish cooperation and encouragement of these men, Schlumberger has developed a substantial service organization in Venezuela and has always made available to them the most modern techniques. In fact, the Dipmeter—now a widely used Schlumberger service—first won unreserved recognition there.

Realizing its responsibility to the industry, Schlumberger has spared no effort to improve constantly its service facilities in Venezuela. With 3 camps, a total of 8 operating centers, 14 skid winches and 31 service trucks already established in Venezuela, Schlumberger invested an additional one million three hundred thousand dollars in 1947 to improve further its service there.

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the Dominguez oil field in Southern California. This water contained:

28,620 ppm of sodium chloride
11,664 ppm of calcium chloride
1,016 ppm of magnesium chloride

The refractive index ($N_D$) of the synthetic formation water was 1.7899 at 66 F.

Kerosine was used in place of actual crude oils in the sand tested. This kerosine was highly purified and filtered before it was used. The refractive index was 2.0892 at 66 F. The chief disadvantage of using crude oils is that it is not known what impurities are actually contained in the oil without exhaustive tests. The ionizing salts are the most important in raising the dielectric constant. It was also found to be much easier to clean the dielectric-constant cell when sands with kerosine were used instead of actual oil sands. Results could be repeated with greater accuracy by using kerosine, which is readily obtainable.

● **Procedure.** Packing the synthetic oil sand in the dielectric-constant cell is the difficulty encountered in this work. Several methods were tried that were unsuccessful. The sand was first packed in a large container, and the dielectric-constant cell, with one end open, was pushed down into the sand like a cookie cutter. Only about three-fourths of the cell could be filled by this technique, so it was abandoned.

The method finally adopted was to measure accurately the actual volume of the annular space in the dielectric-constant cell. A volume of 206 cu cm was obtained for the cell used. A stoppered graduate was weighed and then filled with sand packed to a pore volume of 30 per cent. The actual volume of sand was then recorded and the graduate reweighed. From this, the specific gravity of the dry sand was found to be 1.50 grams per cu cm. The specific gravity of the kerosine tested 0.805 grams per ml. From these known figures, the actual weight of the synthetic sand that is to be placed in the dielectric-constant cell can be readily calculated. The sands are then packed in the cell until the proper weight is obtained.

A large rubber stopper was cut to protect the lead-wires on the bottom of the dielectric-constant cell. The top piece of polystyrene is removed and a thread protector, which was made to keep the threads clean, is screwed over the threads. To keep sand out of the center of the cell, a small rubber stopper was inserted in the inside copper tube. The unconsolidated sand is then poured into the annular space in the cell. Packing is accomplished by vibrating the cell on the rubber stopper and by tamping with a long rod. If the total weight of the cell containing the sand does not agree with the calculated weight, the sand is removed and repacked.

It was found that, as the volume of salt water and kerosine in the sand increased, packing became more and more difficult.

Slight differences in packing appreciably effect results, this more than any other factor.

Temperature was found also to be of importance. When this problem arose, the equipment was set up in a room having a constant temperature of 77 F. A thermometer was mounted in contact with the dielectric-constant cell so that changes in temperature could be noted. When the frequency is between 1 and 4 megacycles, only slight heating of the cell can be noticed. The readings should be taken quickly at these frequencies, and the radio frequency power to the bridge removed. The cell can then be left idle until the temperature again returns to normal. This is only necessary when the sands contain the formation salt water.

Another cause of small errors was the movement of the cell during a run. This was eliminated by resting the dielectric-constant cell in a "V" block. This holds the cell securely throughout the runs.

The following is the procedure used in making the determinations. The signal generator and the receiver are warmed for approximately one hour. The dielectric-constant cell filled with sand, is placed on the wooden "V" block on the bridge, and the ground-lead connected to the ground binding post. The leads to the cell should be kept as short as possible, the length of the ground-lead being only about 1/8 in. The other terminal is connected to the cell by a short lead supplied with the General Radio frequency bridge. This lead is also clipped as close as possible to the center of the cell. Correction factors were used in the calculations for the short connecting lead.

The cell should be in the position in which it is to remain throughout the runs. To obtain an initial balance, a copper bar is inserted between the leads from the dielectric-constant cell. This shorts out the cell entirely. This reactance dial is set on 5000 and the resistance dial on O. The toggle-switch is placed in the "C" position.

When the signal generator is thoroughly warmed, it is set to the desired frequency. The receiver is then tuned to this frequency with the automatic vol-

**FIG. 7. Capacitive reactance to ground of connecting leads as a function of frequency ($X_c$).**

*From operating instructions for Type 916-A Radio-Frequency Bridge.*

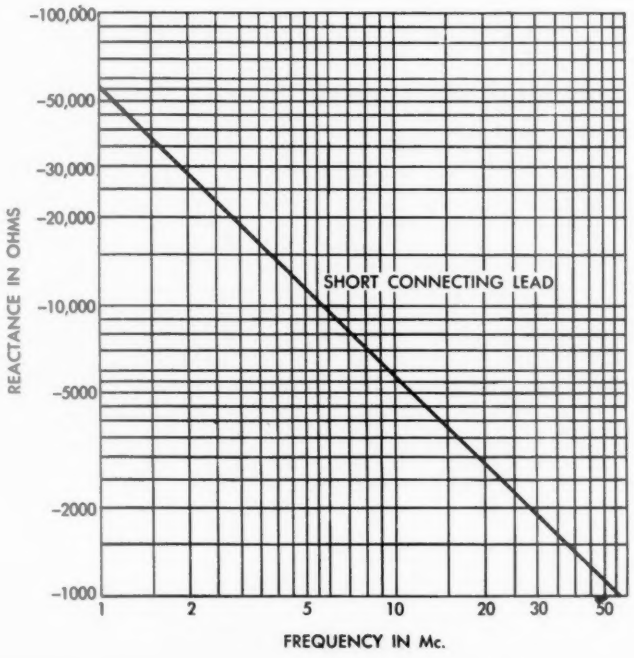
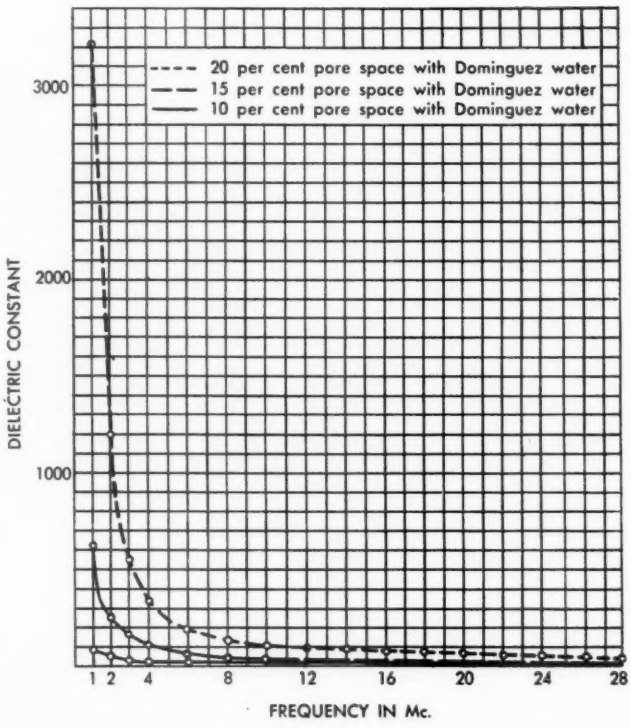



**FIG. 8**


20 per cent pore space with Dominguez water
15 per cent pore space with Dominguez water
10 per cent pore space with Dominguez water
3000
2000
1000
DIELECTRIC CONSTANT
1 2 4 8 12 16 20 24 28
FREQUENCY IN Mc.

# when success is a necessity . . call for the

# Otis Wire Line TUBING PERFORATOR

***No other operations in the field require more efficient service and dependable equipment performance than perforating or cutting tubing.***

**The Otis Wire Line Tubing Perforator, mechanically operated, provides a positive means for performing these operations — *without use of explosives, derrick, mast, drilling mud, pulling unit, or tubing crew.***

**Run under pressure on a steel measuring line, the Otis Tubing Perforator is set on top of a removable stop which can be installed at any depth. By manipulating the line at the surface, jarring down impacts are transmitted through a set of tubing jars made up on top of the Perforator. This action drives a hardened tooled steel wedge behind a metal punch (or orifice insert plunger). Continued downward movement of the wedge drives the punch, or orifice insert, horizontally into and through the tubing wall (see upper photograph). As many holes or as many orifices of desired sizes as needed can be installed at the same or different depths. The entire operation takes only a few hours and is *safe, simple, and successful.***

*ide view of orifice t installed in tubing Otis Tubing Perforator.*

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**When cutting tubing in the well is necessary, that operation can also be performed efficiently with the same mechanically-operated tool used in perforating, by replacing the Perforator punch, or plunger, with a tubing cut-off knife. The Tubing Cutter is then run under pressure on a steel measuring line and operated precisely like the Otis Tubing Perforator by applying downward impacts with the jars. After a single cut has been made the tool is pulled to the surface and a spacer ring added to change location of the knife for the next cut. Successive adjacent cuts, made at the same level (see lower photograph) will completely sever the tubing. However, the tubing can usually be pulled in two after a few cuts have been made, leaving the upper end of the remaining portion of the tubing smooth enough to be engaged with an overshot fishing tool.**

*ide view of tubing h has been cut with Tubing Cutter.*

*Use of the Otis Wire Line Tubing Perforator and Otis Wire Line Tubing Cutter is made available through Otis and affiliated wire line service units stationed in the Gulf Coast, Mid-Continent, California, Eastern, and Wyoming areas (see below). Otis Tubing Perforators and Tubing Cutters may be purchased for use outside the continental limits of the United States through Otis Pressure Control Export, Inc.*

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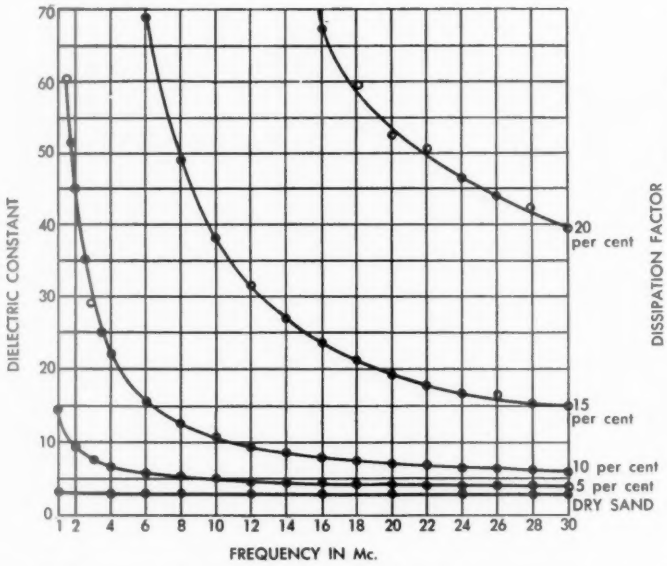



FIG. 9. Per cent of pore space containing Dominguez water.

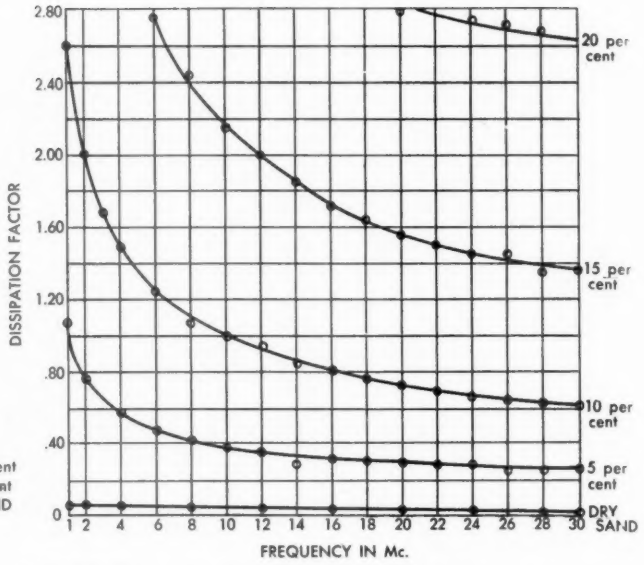



FIG. 10. Per cent of pore space containing Dominguez water.

ume control switch and the "S" meter in operation. The output of the signal generator is adjusted until it registers a maximum on the receiver "S" meter.

The next step is initially to balance the bridge. Two knobs are provided for this purpose, the initial reactance balance, and the initial resistance balance knob. When the null point has been found (the receiver "S" meter aids greatly in this procedure) the copper shorting strip is removed from the cell. Final balance is made by turning the resistance and reactance dials. Readings on these dials are then recorded and another determination is made.

It was earlier stated that both the volume controls were kept at a maximum on the receiver, the output volume being controlled by shifting from earphones to the loud speaker. When this change is made, the "S" meter and automatic volume control are turned off.

The foregoing description of operation of the General Radio frequency bridge is not meant to be a complete explanation, as the instruction manual supplied with the instrument is quite adequate. There are several methods that can be used to improve the quality of the readings obtained on the bridge. These are explained fully in the operating instructions.

● **Derivation of formulas.** The following is the derivation of the general formula used in solving results obtained from bridge readings.

Let:

$Z_1$ = the leg of the circuit containing the variable capacitor $C_A$ and resistance $R_A$.

$Z_2$ = the leg containing resistance $R_B$.

$Z_3$ = the leg containing the capacitor $Z_N$.

$Z_4$ = the remaining leg.

Then:

$$\frac{1}{Z_1} = \frac{1}{R_A} + \frac{1}{XC_A}$$

$$\frac{1}{Z_1} = \frac{1}{R_A} - jwC_A; \text{ where}$$

$$-\frac{1}{jwC_A} = XC_A$$

$$\frac{1}{Z_1} = \frac{1 - jwC_AR_A}{R_A}$$

1. $Z_1 = \dfrac{R_A}{1 - jwC_AR_A}$

2. $Z_2 = R_B$

3. $Z_3 = -\dfrac{1}{jwC_N}$

4. $Z_4 = R_P - \dfrac{1}{jwC_N}$

$$\frac{Z_1}{Z_2} = \frac{Z_3}{Z_4}$$

(General bridge balance when short circuited.)

$$\frac{1 - \dfrac{R_A}{R_A jwC_A}}{\dfrac{R_B}{}} = \frac{-\dfrac{1}{jwC_N}}{R_P - \dfrac{1}{jwC_P}}$$

$$\frac{R_A}{R_B}\left(\frac{1}{1 - R_A jwC_A}\right) =$$

$$\frac{-1}{\dfrac{R_P jwC_P - 1}{jwC_P}} = \frac{C_P}{C_N}\left(\frac{-1}{R_P jwC_P - 1}\right)$$

$$\frac{R_B}{R_A}(1 - R_A jwC_A) =$$

$$-\frac{C_N}{C_P}(R_P jwC_P - 1)$$

$$\frac{R_B}{R_A} - R_B jwC_A = -C_N R_P jw + \frac{C_N}{C_P}$$

$$\frac{jR_B}{R_A} + R_B wC_A = C_N R_P w + j\frac{C_N}{C_P}$$

Real: $R_B wC_A = C_N R_P w$

$$R_B C_A = C_N R_P$$

$$R_P = \frac{R_B C_A}{C_N}.$$

Imaginary:

$$\frac{jR_B}{R_A} = \frac{jC_N}{C_P}$$

$$\frac{1}{C_P} = \frac{R_B}{R_A}\frac{1}{C_N}$$

$$\frac{1}{jwC_P} = \frac{R_B}{R_A}\frac{1}{jwC_N}$$

When the short-circuit is replaced by the unknown impedance, $Z_x = R_x - jX_x$, the new balance equations are:

$$R_P + R_x = R_B\frac{C_{A_2}}{C_N}.$$

$$jX_x + \frac{1}{jwC_{P_2}} = \frac{R_B}{R_A}\frac{1}{jwC_N}$$

The unknown resistance, $R_x$, and reactance, $X_x$, are therefore related to the bridge parameters by the following expressions:

$$R_x = \frac{R_B}{C_N}(C_{A_2} - C_{A_1})$$

$$X_x = \frac{1}{w}\left(\frac{1}{C_{P_2}} - \frac{1}{C_{P_1}}\right)$$

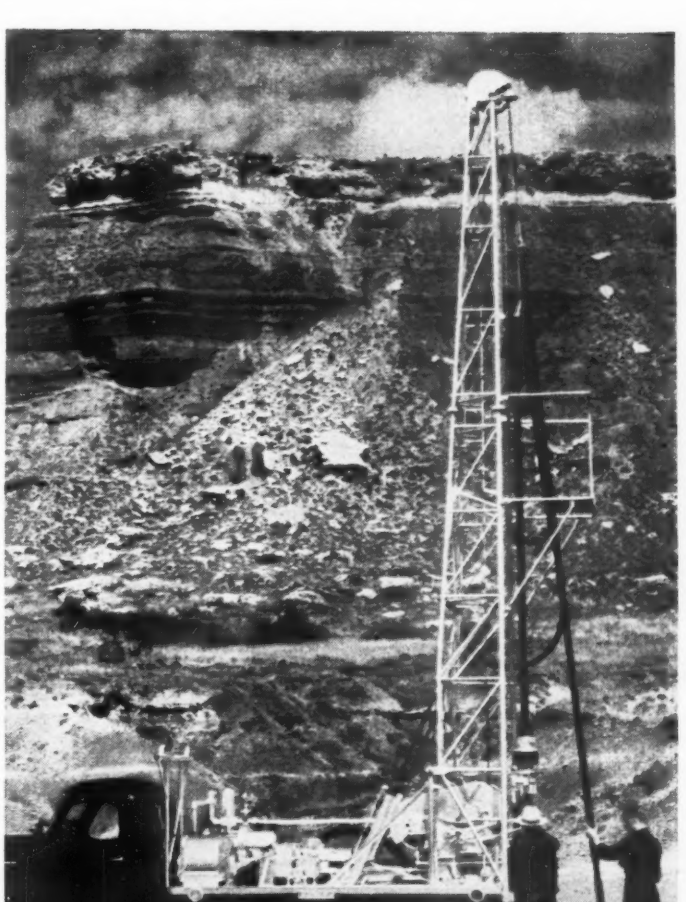
● **Sample calculations.** For example, consider a frequency of 1 mc on the 20 per cent of pore space occupied by kerosine.

$R_e$ = the difference of the readings on the resistance dial.

$R_e = 184 - 0 = 184$ ohms.

The effective series resistance of the

# ALL THROUGH THE OIL INDUSTRY



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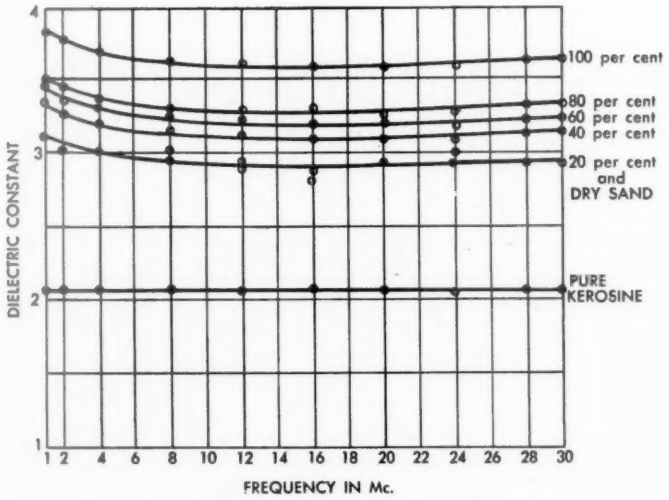



FIG. 11. Per cent of pore space occupied by kerosine.

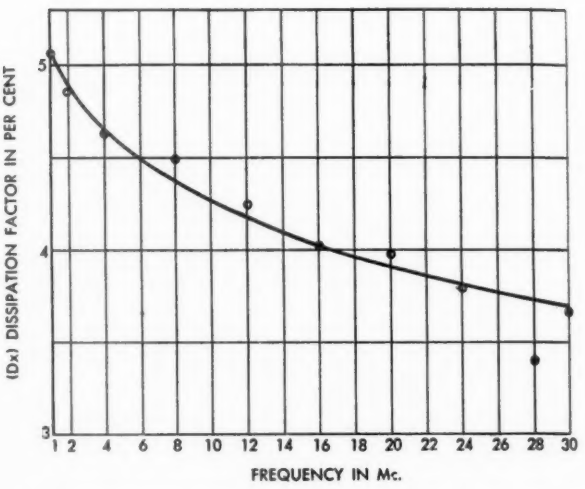



FIG. 12. Twenty per cent of pore space occupied by kerosine.

reactance condenser $C_p$ as a function of frequency and dial setting is negligible throughout these determinations.

$X_e$ = the difference of the readings on the reactance dial divided by the frequency of the run.

$$X_e = \frac{138 - 4000}{1} = -3862 \text{ ohms.}$$

The following equations apply lead corrections to both $R_e$ and $X_e$.

$$R_x = R_e\left[1 + 2\frac{X_e}{X_a} - \left(\frac{R_e}{X_a}\right)^2\right]$$

$$X_x = X_e + \frac{X_e^2 - R_e^2}{X_a}$$

$X_a$ is the capacitive reactance to ground of the connecting leads.

From these calculations, the capacitance is found from the following equation:

$$C_x = \frac{10^6}{2\pi F X_x}$$

The dissipation factor is:

$$D_x(\%) = R_x/X_x \times 100$$

The dielectric-constant is calculated by:

$$K = \frac{C_x \text{ (cell + sample)}}{C_x \text{ (empty cell)}}$$

All the dielectric-constant cell calculations are made using the general formulas shown above. The headings on the data sheets labeled corrections are:

$$\left[1 + 2\frac{X_e}{X_a} - \left(\frac{R_e}{X_a}\right)^2\right]$$

$$\frac{X_e^2 - R_e^2}{X_a}$$

● **Results.** The general pattern of the samples containing the Dominguez water shows a rapid decrease in the dielectric constant from 1 megacycle. This is only true, however, for substances containing non-polar molecules. As can be noted in Fig. 11, the lines for dry sand, kerosine, and sand containing kerosine are all practically straight. The ordinate in Fig. 11 has been greatly extended.

The reason for the rapid decline between 1 and 8 megacycles is that the molecules are at the point where the dipole rotation ceases to add to the dielectric constant.

Dissipation factor of the sand containing the salt water ceases to have any meaning above the 10 per cent pore volume saturation. The salt water has formed a complete phase between the sand grains and acts as a conductor. Only the dissipation factor for the 20 per cent of pore space occupied by kerosine was plotted in Fig. 12. The reason the remaining curves are not presented is that they are all nearly the same.

In Fig. 11, which shows the dielectric constant of pure kerosine, sand, and containing kerosine, the reason for the gradual increase of dielectric constant with the increase of kerosine in the pore spaces is that when the sand is packed in the cell, complete contact is not made with the dielectric constant cell walls. This makes the dielectric constant of dry sand lower than that of a solid piece of quartz. The dielectric constant of fused quartz is 4.2[1].

The results shown here are in fair agreement with Schutz and McMahon.[2] They show the dielectric constant of brown river sand, finer than 100 mesh, to be 2.73 at 20 megacycles. The density to which the sand was packed is not mentioned. For dry silica sand at the same frequency the dielectric constant determined by the method described in this paper was 2.93.

The accuracy of these results is estimated to be within 6 per cent. Tests on 28 and 30 megacycles run slightly higher, as the output of the signal generator was low, thus impairing the sensitivity of the bridge. Mention has been made of the important variations and the methods used to eliminate them. One error, however, has not been considered in the results. This is the fringing or electrostatic end effects. The only way to completely eliminate this error would be to design a cell with a ring-guard on both ends, and eliminate the polystryene holders. This would be a rather difficult problem when it is considered that the cell must also be filled with unconsolidated sands.

The percentage error of the end effects can be estimated by using Kirchoff's formula:

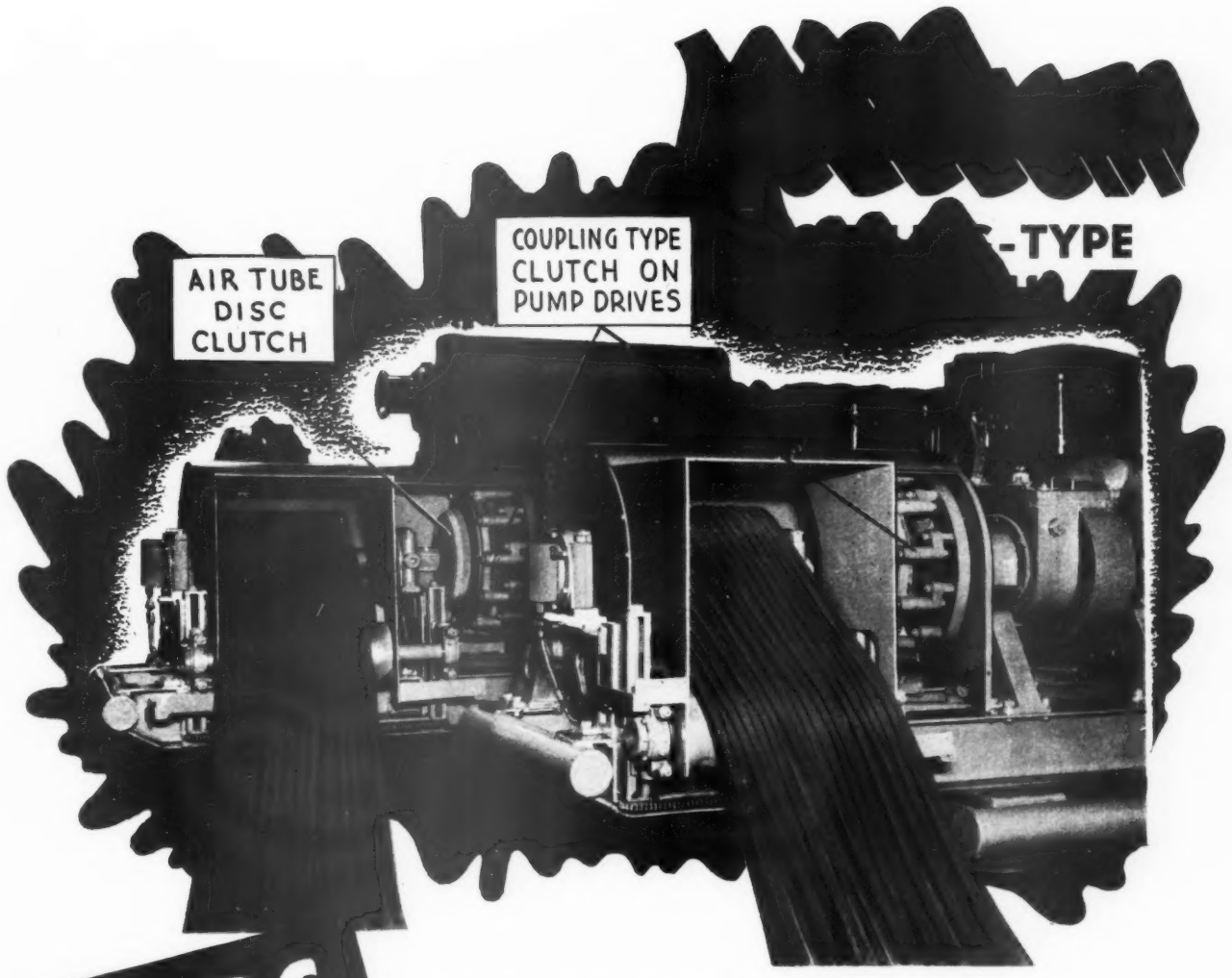
$$\text{Edge correction, (per cent)} = \frac{1}{\pi r}\left[\frac{d \log_e 16\pi(d+b)r}{d^2} + b\log_e\frac{d+b}{b} - 3d\right]$$

where r is the radius and b the thickness of the disk electrodes, and d is their distance apart (thickness of sample). This correction is for parallel plate condensers. The percentage error was calculated from this formula, assuming parallel plates having the same area as the mean diameter times the length of the cell. The per cent error per unit of circumference was calculated and applied to the coaxial cylinders. The error using the following figures was 8 per cent.

| | |
|---|---|
| Mean circumference = | 12.42 cm |
| Length = | 22.7 cm |
| Area of plates = | 282.0 cm |
| r = | 9.48 cm |
| b = | 0.3 cm |
| d = | 1.25 cm |

The severity of the effect is limited somewhat by the fact that polystyrene ends are used, and also, that to obtain the dielectric constant the empty cell capacitance is divided into the capacitance of the cell containing the sample.

The index of refraction of kerosine when squared is equal to 2.0892. The dielectric constant of kerosine at 30 megacycles is 2.06. Assuming that further changes in dielectric constant are not appreciable, the dielectric constant is only in error by 1.5 per cent.




# STOPS ALL IDLING WEAR IN PUMP DRIVE CLUTCHES

It is now a well known fact that almost all wear on pump clutches occurs when the clutch runs disengaged. The Wilson Coupling Type Clutch eliminates this wear almost entirely! With the clutch disengaged, only the friction disc rotates and this *without measurable friction.* No other parts of the clutch move, and the bearings are absolutely stationary. Pulley is rigidly keyed to shaft and *there are no bearings in the pulley to cause trouble.*

The flexible coupling is rubber and fabric link type, which combines a cushion shock absorber in the drive system with a "weak link" to prevent damage to more important parts such as the engine crankshaft, in the event of excessive misalignment.

This Coupling Type Clutch can be furnished with either Wilson Air-Tube Disc Clutch or Mechanical Disc Clutch . . . spacing is the same for both clutches. The Air-Tube Clutch is the newest and most perfect clutch ever installed on a drilling rig. No adjustments are required. There are no diaphragms, packing or gaskets. All air connections are outside the clutch and easily accessible. *One* Air-Tube energizes *two* or *four* friction faces by direct axial pressure. All wearing parts are easily and cheaply replaced *without removing shaft!* The clutch has maximum torque capacity and is unaffected by centrifugal force.

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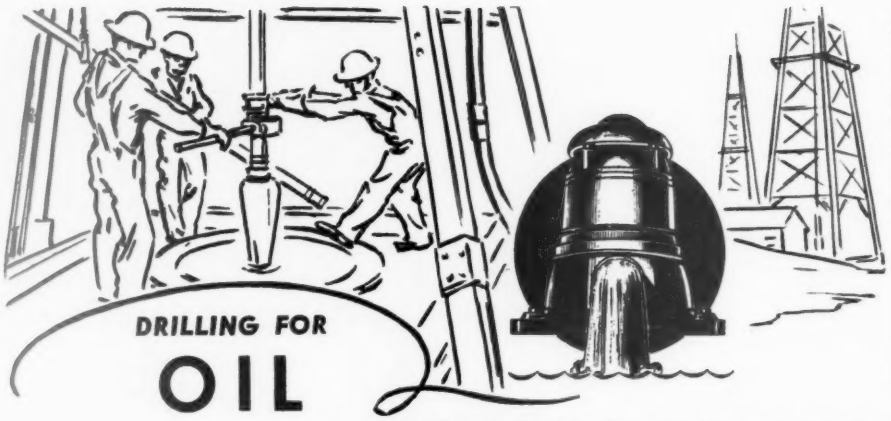


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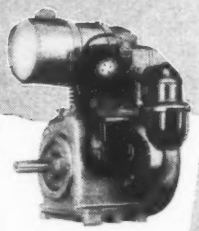
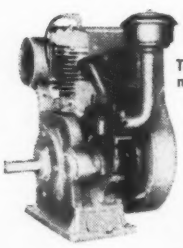
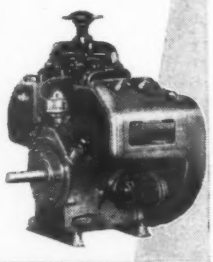
Wisconsin Engines are worth looking into on all counts. Your interest will be heartily reciprocated.



Typical 4-cycle single cylinder model, 2 to 4 Hp.



Typical single cyl. model, 4 to 9 Hp.



Typical V-type 4-cylinder model, 15 to 30 Hp.

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● **Conclusions.** The results obtained with the sands presented here are incomplete. Different types of sands, oils, and formation-waters should be tested. A more complete picture of the dielectric properties should also include resistivity measurements, especially on the sands containing high percentages of salt water.

A wider range in frequency would be of advantage, especially between 600 kilocycles and 1 megacycle. The results show only the drop in dielectric constant where the dipole rotations cease to have their effect. The dielectric constant curve should flatten out at lower frequencies. This portion is not shown on the graphs.

For further work, a cell of different design would be of advantage. If a single packing could be made and the various liquids added to the cell to increase the percentage of saturation, results would be more reliable. This, however, would take considerable time for the liquids to distribute themselves equally. The cell should also be designed with guard-rings.

● **Acknowledgments.** I would like to express my appreciation to those who have so generously given of their time and experience in cooperating on this thesis. I wish particularly to thank Prof. F. G. Tickell of the Department of Mining Engineering, Stanford University, for his aid in editing this material; Dr. F. E. Terman, dean of the School of Engineering, Stanford University, for his helpful criticism; P. H. Jones of the Union Oil Company for his cooperation in obtaining laboratory space and equipment at the Union oil refinery at Wilmington, California; Dr. H. W. Ritchey who aided in the theoretical aspects of this problem; Dr. Nielsen of the Westinghouse High Frequency Laboratory; Frederick Ireland of General Radio Company, and R. C. Wheeler for the loan of the radio receiver used throughout this work.

● **References.**

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★ ★ ★

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## Roller bearings give maximum efficiency where there is complete rotation

For an indication of quality in pumping units, look at the bearings!

Note that the crank and lower connecting rod, illustrated, are equipped with *double roller self-aligning roller bearings*. These bearings are grease-lubricated and enclosed in weatherproof one-piece steel housings equipped with grease seals, Alemite and pressure relief fittings. Steel wrist pins with tapered shanks are an added feature.

Check next, the D-6 Reduction Gear, illustrated above. It is a double reduction type with fully heat-treated and machine-cut gear teeth of the single helical type having long and short addendum tooth form. The crankshaft and high-speed pinion shaft, extending through both sides of the gear case, are mounted on *shim adjustable, large capacity tapered roller bearings*. This feature provides for maximum operating efficiency and long life.

In every instance lubricant is sealed in . . . dust and grit are sealed out with replaceable oil seals.

SPECIFICATIONS

| A.P.I. Peak-Torque Capacity at 20 S.P.M. Inch-Pounds | A.P.I. Polished-Rod Load Capacity Pounds | Stroke-Range Inches |
|---|---|---|
| 32,200 | 6,900 | 20¾ to 30 |

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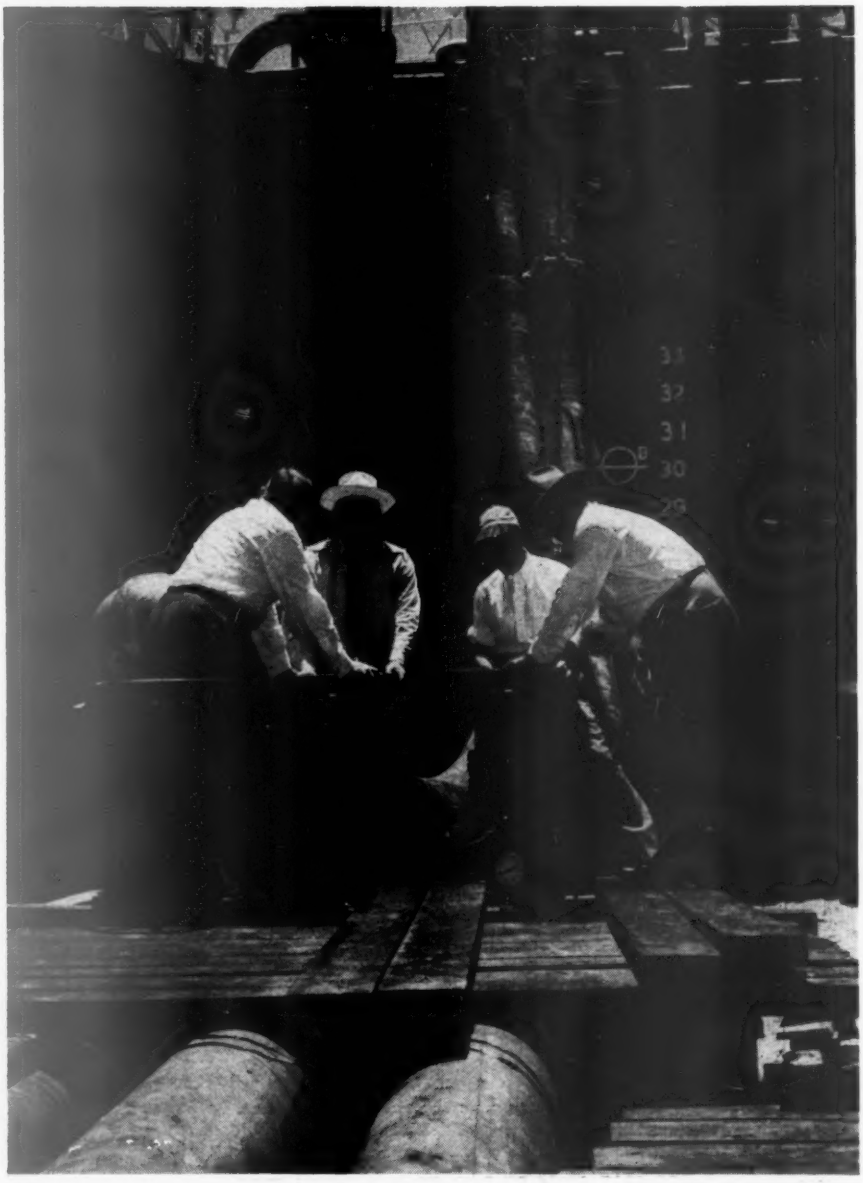


**Sun Pipe Line Company of Texas began operating its new deep water terminal at Ingleside, near Corpus Christi in April. Shown turning valves are, left to right: R. W. Pack of Philadelphia, director of the parent Sun Oil Company; S. E. Ogle of Beaumont, vice-president and chief engineer; Hill Sanders of Beaumont, vice-president and general manager; and W. C. Kinsolving of Philadelphia, president.**

# Deep water terminal

SUN PIPE LINE COMPANY (Texas) has begun operating a new deep water terminal at Ingleside, near Corpus Christi, to speed the movement of crude oil from Southwest Texas producing fields.

The terminal completes a crude oil pipe line system begun in 1946 and provides a new tidewater outlet for crude oil destined for eastern shipment.

It permits Sun Pipe Line Company (Texas), independently managed subsidiary of Sun Oil Company, to discontinue the use of pipe lines and docking facilities of other companies at Harbor Island and thus to have a completely integrated system.

The SS Sabine Sun took aboard the initial cargo from the million-barrel storage tank farm that forms the northern extremity of a gathering and trunk system extending from Sun field in Starr County, near the Mexican border, to the new terminal.

The trunk system includes 244 miles of pipe lines, ranging in size from 4-in. to 10-in. pipe, and links the new terminal with 23 separate oil fields.

William C. Kinsolving, president of Sun Pipe Line Company (Texas), was in charge of a brief ceremony marking the first tanker loading. A barbecue followed.

Built on a 200-acre tract of land on the northeast side of Corpus Christi Bay, the new installation contains complete storage, wharfing, pumping, and loading facilities.

Ample room is available for the expansion of facilities as the flow of crude from Southwest Texas increases.

Operations at Ingleside will be under the direction of F. Hill Sanders, vice president and general manager of Sun Pipe Line Company (Texas). J. T. Butterfield, Southwest Texas district superintendent, will be in charge of actual field operations.

● **Ingleside terminal.** The terminal consists of seven steel tanks, four with cone roofs and three with floating roofs, each tank having a capacity of 131,000 bbl. Aggregate storage capacity is 917,000 bbl.

The terminal's pumping station is equipped with three electrically-driven centrifugal cargo pumps, each capable of delivering 7500 bbl an hr through two 16-in. cargo loading lines. An additional centrifugal transfer pump will be used in moving oil about the farm.

The wharf is built of steel sheet piling of T-Head coffer dam type construction, 145 ft long by 35 ft wide, completely filled with sand and topped with road dressing. Additionally, there are two steel caisson-type mooring clusters, one at either end of the T-Head.

The T-Head is reached from shore by a steel and timber runway extending into the bay some 700 ft where a dredged turning basin, triangular in shape and 38 ft in depth adjoins the deep water channel from Corpus Christi to the sea. The ships will lay adjacent to the ship channel and with the aid of Seamule tugs can cast off their lines and proceed independently from that point. This T-Head will accommodate the largest of vessels with ease.

All modern type appurtenances have been used on shore as well as on the wharf, such as electrically operated master control gate valves, air operated winches and hoists, and patented swivel joints on the hose connections. The 16-in. cargo loading lines can supply the ships at any rate they desire, from 1000 bbl per hr to 20,000 bbl an hr; and in an emergency due to power failure gravity loadings can be accomplished at a rate of 7000 bbl per hr.

Facilities have been installed to take

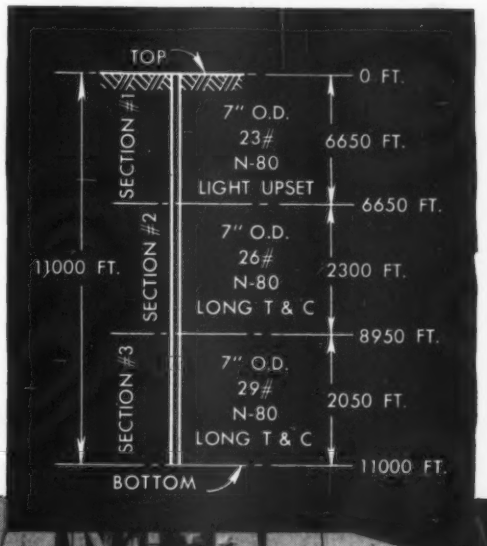
# *You can save...* by using COMBINATION casing strings

THE term "combination casing" is generally applied to a casing string composed of more than one weight per foot, or more than one grade of steel, or of both.

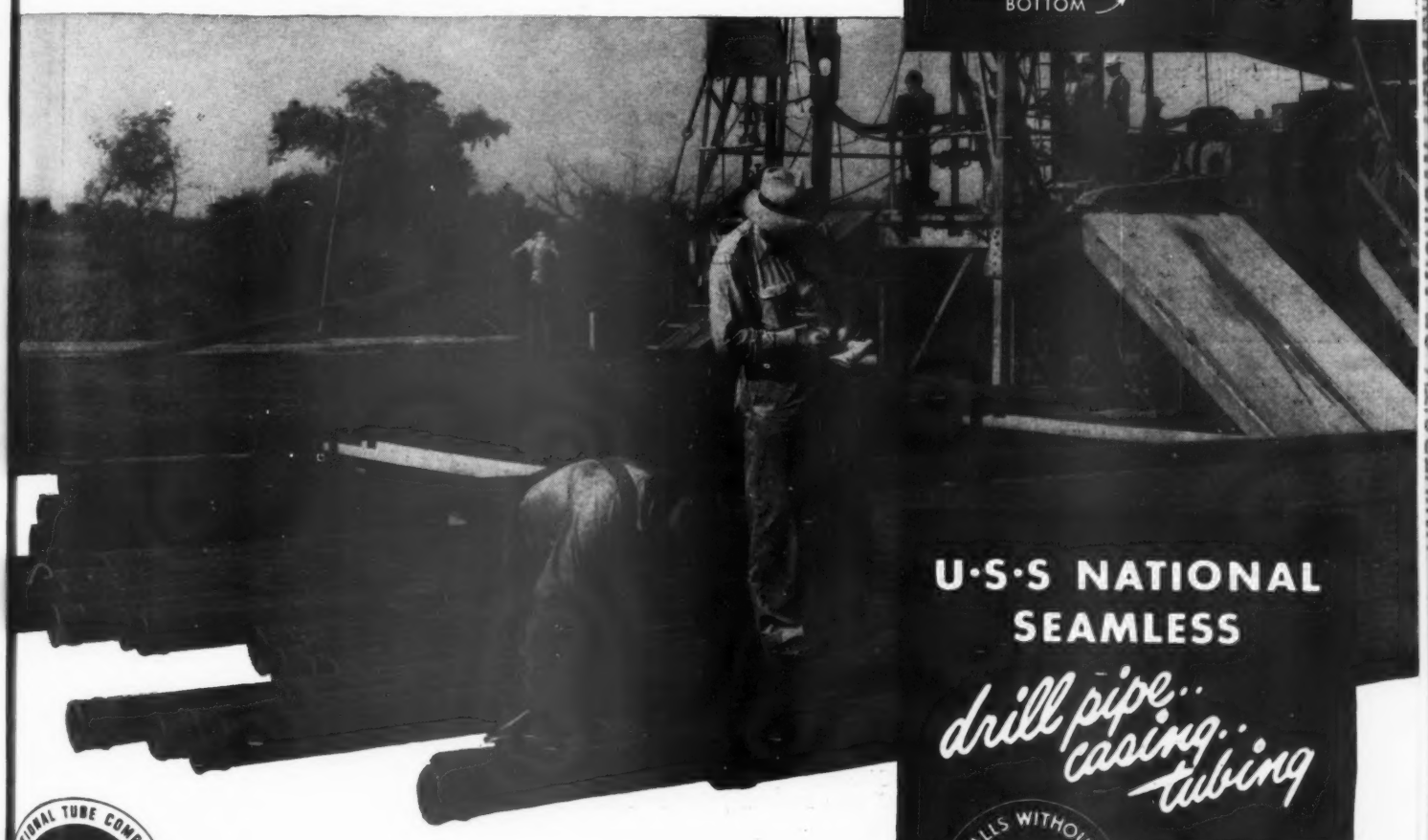
Under certain conditions, substantial savings can be effected by a suitable combination of weights and grades of casing, particularly when used in deeper wells.

For example take the 11,000 foot well shown in the accompanying chart. With a combination string as shown the weight totals 272,200 pounds. If the heaviest casing had been used all the way down, the weight would have been 319,000 pounds, or 46,800 pounds more.

National Tube Company has prepared a booklet entitled, "Combination Casing Strings" which gives complete calculations for wells from 3,500 to 16,100 feet deep and for casing 5½" to 7" O.D. This booklet which supplements National's Bulletin No. 15, Seamless Drill Pipe, Casing, and Tubing will give you valuable help in planning your casing strings. Write for a copy if you do not have one — National Tube Company, Frick Building, Pittsburgh, Pennsylvania.




**A typical design for an 11,000-foot casing combination string which weighs 46,800 pounds less than the conventional string. For details of design see National Tube Company Bulletin No. 15.**



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of shock, strain or vibration the pipe will fail before the WEDGE reinforced joints. Stronger joints permit the use of economical THIN WALL pipe. WEDGE Chill Rings eliminate costly maintenance. Laying time is shortened by their quick, positive positioning feature. Result? A real savings to you!

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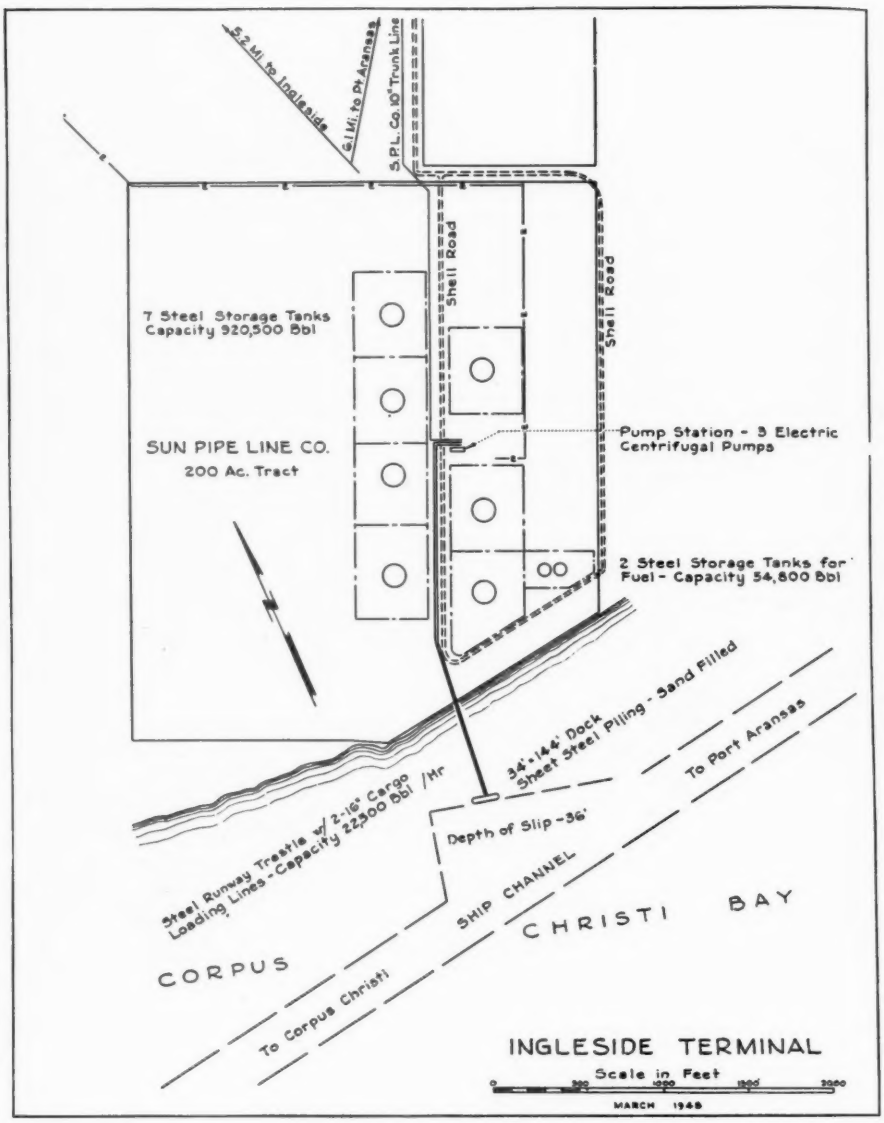



**Map of Sun Pipe Line's deep water terminal.**

the ballast from the ships on arrival and to supply ships with bunker fuels and fresh water. The entire tank farm has been enclosed in a cyclone fence, and roads constructed along the outside of the property to enable vehicles to proceed from the end of the runway to the neighboring towns without going through the tank farm proper.

Crude oil handled by the Ingleside terminal is gathered in the fields listed below and is transported to the terminal via 244 miles of main trunk line, the pipe ranging in size from 4-in. to 10-in.

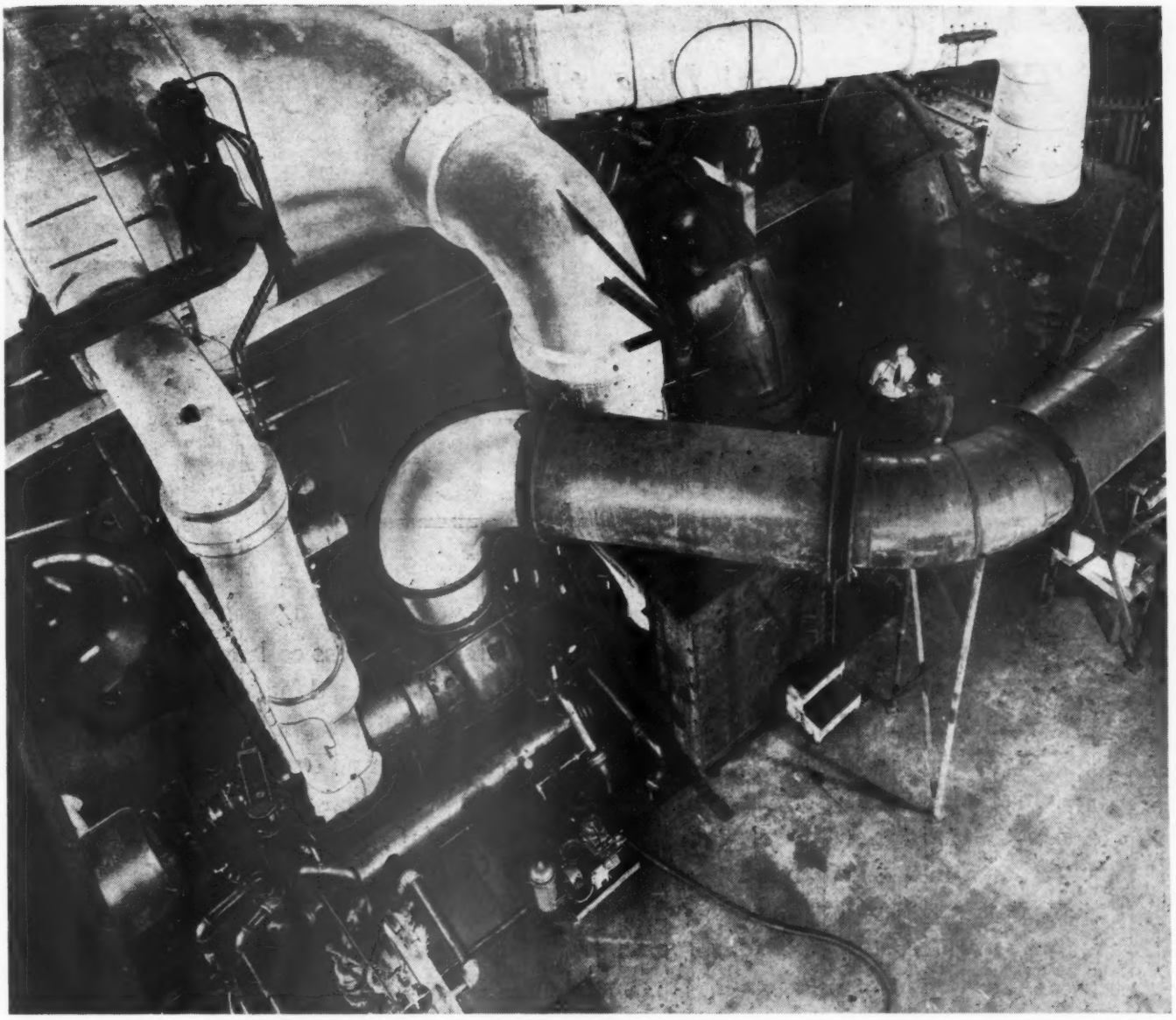
Garcia, Boyle, Yturria, Ross, Frost, Flores, North Rincon, Sun, North Sun, Alta Mesa, Sullivan, Canales, Tijerina, North Magnolia City, Seeligson, La Gloria, Aqua Dulce, Guerra, Weil, Charco Redondo, Holland, East and La Reforma.

The general contractor was Lee Aikin, Corpus Christi, Texas, clearing, roads, buildings, concrete foundations, tank foundations, and all pipe work. The tank contractors were: Bethlehem Steel Company, four 131,500 bbl cone roof storage tanks and two 27,400 bbl cone roof fuel tanks. Chicago Bridge and Iron Company, three 131,500 bbl pontoon roof storage tanks. The dock contractor was Austin Bridge Company, total off-shore construction of runway, dock and mooring caissons. The dredging contractor was Standard Dredging Company, berthing slip to depth of 36 ft.

● **River Rouge terminal.** Sun Oil Company has also begun operation of a new terminal at River Rouge, Michigan, which combines deep water, railroad, trucking, and pipe line facilities. Key installations include 44 storage tanks with a total capacity of more than 8,000,000 gal, facilities for compounding and blending basic grades of lubricating oils into specialized products, a warehouse, an office building, and a testing laboratory to insure uniform quality of products.

The warehouse platform is large enough to load 25 trucks at one time. Six box cars and eight tank cars can also be loaded simultaneously.

The River Rouge terminal will supplement the Hamtramck terminal in handling Sun products throughout Detroit and the surrounding territory. ★★



Gas turbine unit at U. S. Naval Experiment Station. Insulated turbine exhaust header and regenerator at upper left.

# Gas turbine plant for 1500 F operation

By H. A. ALTORFER,* Allis-Chalmers Manufacturing Company

EXCLUSIVE

EXTENSIVE industrial application of the gas turbine has been limited to the refinery where it is used to drive air compressors in the Houdry Process for the cracking of crude petroleum. Wider application of gas turbine prime movers in recent years has indicated that turbines should be designed for operation at temperatures up to 1500 F. Field experience gained with the Houdry equipment, which operates at temperatures of less than 1000 F, has not provided an entirely adequate background for the construction of such turbines. The Bureau of Ships of the U. S. Navy therefore arranged for the Allis-Chalmers Manufacturing Company, which already had a number of Houdry gas turbine units in operation, to design and construct a 3500-hp experimental gas turbine plant capable of operating at temperatures up to 1500 F. The equipment is installed at the U. S. Naval Engineering Experiment Station at Annapolis, Maryland, and has now been in operation for more than three years.

Being an entirely experimental gas turbine unit, thermal efficiency was not given first consideration in its design. In this project, the governing design factors were flexibility of operation, ease of taking essential research data at hundreds of points during each test run, and facility of complete disassembly of any or all component parts for scheduled inspections as the tests progressed.

The plant consists essentially of two

*Turbo-Power Development Department.

*The better you live, the more oil you need...*

# A report on the most useful year

**IN this country and through the world, human progress calls for more and more oil. To do their part in meeting the great need for oil in 1947, Standard Oil Company (New Jersey) and its affiliates performed the biggest job in their history. They produced more oil and delivered more products; took in and paid out more money; employed more workers and served more people than ever before. And far more than ever was spent for facilities to meet growing needs—426 million dollars in a single year, paid for out of past and current earnings of the business. It was a year of great accomplishment; great progress. Here are some highlights from this significant year, based on the Company's Annual Report to its 171,000 stockholders...**

1 **World-wide, the need for oil surpassed all records.** To help meet the need, crude oil production by Jersey Company affiliates was increased 8% over 1946, setting another new record. Their production was 14% of the world's total for the year.

2 **In the U.S., too, the need was at record levels.** Three million more cars to fuel than pre-war; twice as many tractors and trucks on farms; a million and a half more oil-heated homes; five times as many diesel locomotives. Total U.S. consumption of oil products was 11% greater than 1946, 12% greater even than the peak war year. In meeting this need, we set new output records month after month, accounting for 9% of U.S. total crude oil.

3 **The unusually hard winter** made heating oil and kerosene supply a special problem. By extraordinary effort in refineries and hard work and long hours by people all along the line, we were able to deliver about 25% more of these products than in the winter before.

4 **With such big demand, big supply, and rising prices,** money came in — and was paid out — in all-time record figures. Total dollar income reached $2,387,000,000 — 45% over 1946. Operating charges and other deductions from income reached $2,118,040,000 — 44% over 1946. A record sum of $466,954,000 was paid to our employees.

## STANDARD OIL COMPANY

AND AFFILIATED

# biggest, hardest, we ever had!...

5 **Net consolidated earnings** of the Company and affiliates — $269,000,000 — equalled $9.83 per share, or 11.3% of total income as compared to 10.8% in 1946. Dividends of $4.00 per share were paid by the parent Company.

6 **Most important dollar figure of the year** was the 426 million dollars spent for new wells, plants, tankers, pipelines and all the other things it takes to get the oil you need. Part of a billion dollar program covering the two years 1947-48, it was by far the greatest capital investment we have ever faced. The money came almost entirely from earnings, past and current — money made on the job went back into the job.

7 **Transportation of oil was a big job.** During the year, we bought 23 ocean-going tankers from the U. S. Maritime Commission, and early this year we ordered 6 new 26,000-ton, 16-knot ships, the largest we ever operated. Pipelines were pushed to new records — our trunk lines delivering 83 billion barrel-miles, or 11 billion more than in 1946.

8 **In discovering new oil,** we spent 5 times as much as pre-war — 16% more than last year. (Altogether, the country's known oil reserves were increased by 600 million barrels during the year, in spite of record consumption.)

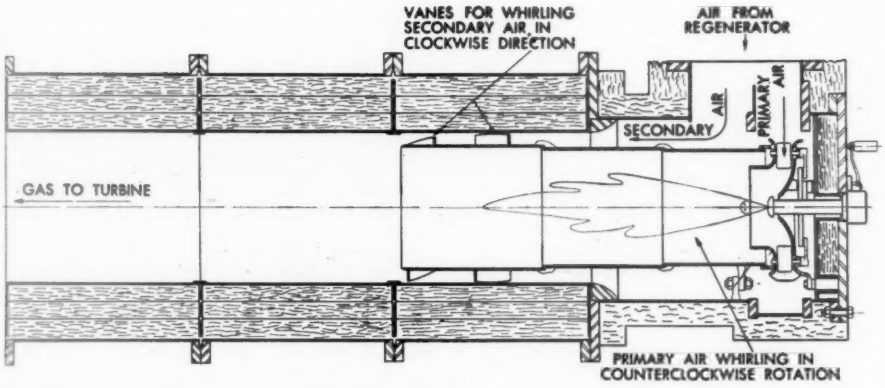
9 **Cost of research also increased** — $18,200,000 was spent for new knowledge. Considerable progress was made in finding more efficient and lower-cost processes for making gasoline and other liquid fuels synthetically from natural gas, oil shale, and coal.

10 **Labor-management relations** remained excellent, continuing our exceptional record of industrial harmony. Employee compensation was adjusted upward during the year to help meet rising living costs. A total of $55,396,000 was saved in employee Thrift Plans, of which $20,987,000 was saved by employees and $34,409,000 contributed by the Company and its affiliates.

**THE 1947 JOB WAS A BIG ONE. The jobs ahead are bigger still. In a democracy the responsibility for making a better world rests with the individual and the individual enterprise. It is clear that an enterprise like Standard Oil Company (New Jersey) must exercise a full realization of the social responsibilities of profit—must understand that the peace, advancement, and the security of the people of the world are the best guarantee of the Company's own progress and security. We intend now, as always, to demonstrate in action that the free, competitive American enterprise system is far superior to any other. We believe that the Company and its affiliates are so organized, and their business so conducted, that they will continue to serve people well.**

(NEW JERSEY)
COMPANIES

*Copies of the full report are available on request. Address Room 1626, 30 Rockefeller Plaza, New York 20, N. Y. The earnings statement in this report satisfies the provisions of Section 11 (A) of the Securities Act of 1933.*


VANES FOR WHIRLING SECONDARY AIR IN CLOCKWISE DIRECTION
AIR FROM REGENERATOR
SECONDARY AIR
PRIMARY AIR
GAS TO TURBINE
PRIMARY AIR WHIRLING IN COUNTERCLOCKWISE ROTATION

**Combustion chamber for experimental gas turbine plant at U. S. Naval Engineering Experiment Station.**

**Insulated nozzle chest and inlet liner of the compressor turbine prior to insertion into the outer rolled steel casing.**

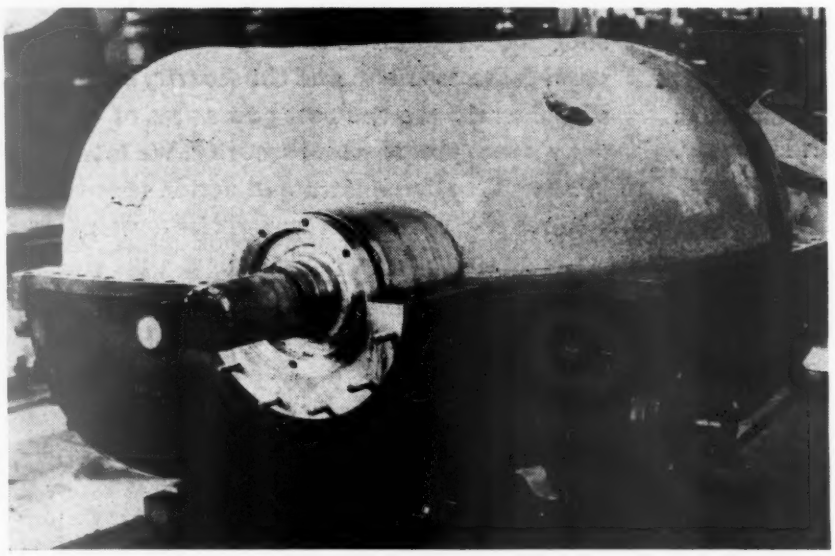
**Insulated nozzle chest and inlet liner of one of the turbines encased in one-half of the outer rolled steel casing.**

gas turbines, an axial flow compressor, a heat exchanger or regenerator, two combustion chambers, and a dynamometer, together with the necessary piping and auxiliary equipment. One turbine, designated as the gas generator turbine, drives the axial flow compressor, and the second turbine, designated as the power turbine, drives the dynamometer, which absorbs and accurately measures the output of the turbine.

The cycle selected for the unit is known as the parallel turbine regenerative cycle. Although other cycles might have been used to obtain high thermal efficiency, this cycle offered the greatest flexibility. Air enters the compressor at atmospheric pressure and is compressed to 45 psig. The compressed air then enters the heat exchanger where it is heated by the turbine exhaust gases from a temperature of 365 F at the compressor discharge to a temperature of 750 F. After leaving the heat exchanger, the preheated air flows directly downward into the two horizontal combustion chambers, one for each turbine.

Each combustion chamber is supplied with a single oil burner in which the liquid fuel is broken up by mechanical atomization into extremely fine particles to promote rapid burning. The present unit is operating with No. 2 furnace oil, because of its availability at the station. In an ultimate installation it is probable that fuels of grades as low as bunker C fuel oil will be used.

The central flame tube is arranged to pass the proportion of air necessary to support and complete combustion. The remainder of the air flows between the flame tube and the outer wall of the combustion chamber, thereby reducing the temperature of the flame tube to a safe operating level and at the same time avoiding the use of refractory brickwork. The cooling air and combustion gases are then intimately mixed by allowing the oppositely whirling concentric streams to come together at the end of the flame tube.



The heat released in these combustion chambers at full design load is approximately 2,500,000 Btu per cu ft of flame tube volume per hour, which is several times the heat release of the ordinary high capacity central steam boiler. The gases leave the combustion chambers at 1500 F and enter the heat exchanger at 1025 F and escape to the stack at 637 F.

An important phase in the design and construction of the unit was the insulation of the various pieces of equipment. Today, after a considerable amount of testing, the materials and the methods of application have proved themselves practical and are continuing to be satisfactory.

● **Insulating materials.** Equipment is insulated with two materials used either separately or in combination, depending upon the operating temperature. For temperatures up to 600 F, the insulation is 85 per cent Magnesia; for temperatures between 600 and 1025 F, a diatomaceous silica type of insulation is used in combination with the 85 per cent Magnesia. For temperatures above 1025 F, the diatomaceous silica is used alone. Although its thermal conductivity is higher than that of 85 per cent Magnesia, diatomaceous silica is more resistant to the effects of high temperatures and it is, therefore, used as an inner layer to protect the magnesia insulation.

Both materials are molded products in the form of blocks and pipe insulation; 85 per cent Magnesia is a mixture consisting of 85 per cent magnesium carbonate and asbestos fiber. Diatomaceous silica is a naturally occurring material made up of fossilized microscopic plants, called diatoms, and a binding ingredient such as asbestos fiber. Besides having low thermal conductivity, the structure of these materials is such that they can be handled and applied easily.

Both materials are resistant to cracking or loosening upon being subjected to alternate heating and cooling. This characteristic is especially important in the Annapolis installation, because the equipment checkup at the end of each test run means that the insulation is alternately heated to operating temperature and cooled to room temperature.

The insulating materials are finished with a hard coat of asbestos cement to seal the joints in the insulation and to protect them from damage.

● **Gas passage piping.** The gas passage piping that conducts the gases at 1500 F from the combustion chambers to the inlets of the two turbines was a critical item in the design of the plant. Special attention had to be given to the methods used

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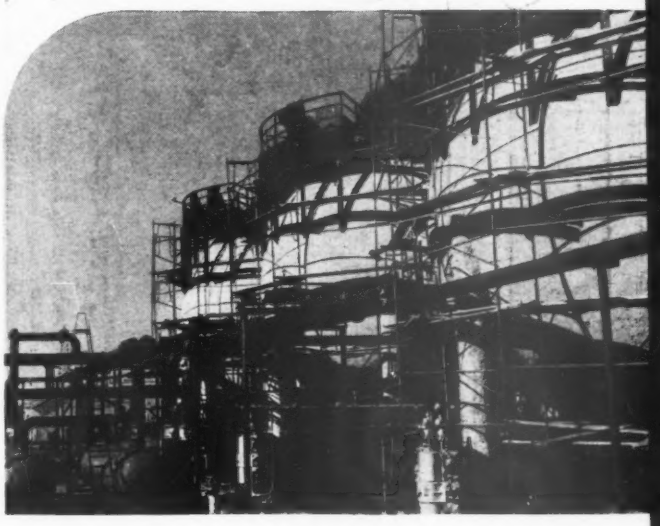

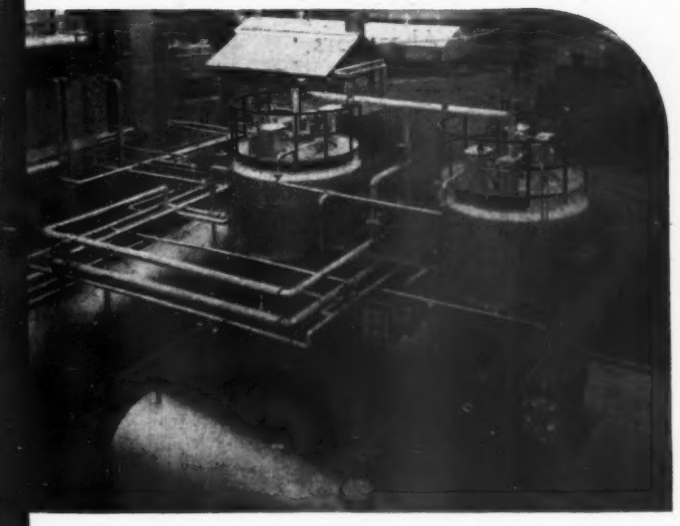

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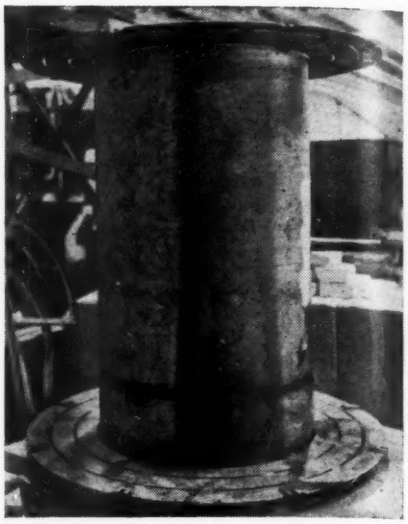
PR 47-M

for taking care of metal expansion resulting from the high temperatures involved. Provision was made for the piping as well as all other equipment to expand ⅛ in. per ft in all directions when heated to 1500 F and still remain pressure-tight. With the large piping involved, an efficient, practical method of insulation had to be devised so that heat losses would be kept at a minimum.

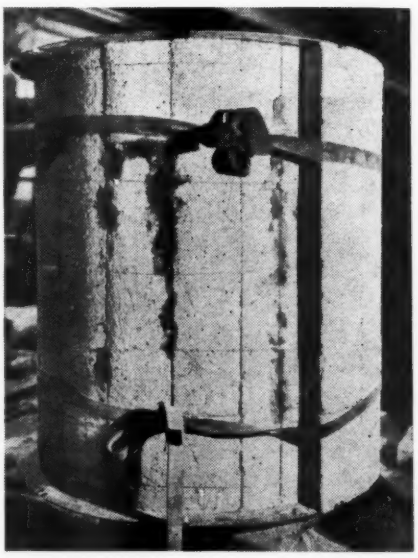
The gas passage piping consists of an inner stainless steel liner or pipe, with an inside diameter of 26 in. built in 4-ft sections to allow for expansion; a triple layer of 3-in. thick blocks of diatomaceous silica; and an outer casing of ordinary ¼-in. thick rolled steel. To keep the insulated liner from riding on the outer casing, each 4-ft section is supported by a thin, circular, metal fin, 9 in. wide, welded to each end of the section.

With the use of slotted construction of the support fins and by spot-welding them to the stainless steel sections, the amount of heat conducted by the fins to the outer casing is kept to a minimum. As these support fins offered a possible path of heat flow, determination of the optimum thickness of insulation for the gas passage piping presented an interesting problem.

The thickness of the support fins depended upon the amount of insulation to be used on the piping; the thicker the insulation the thicker the support fins had to be to support the added weight.



**A 4-ft section of stainless steel liner of gas passage piping with slotted support fins, before insulation was applied.**



**Partially insulated section of stainless steel liner of the gas passage piping. After top layer was applied, insulation was covered with a hard finish cement.**

On the other hand, the thicker the support fins the greater the amount of heat conducted from the inner piping to the outer casing via the fins. Calculations indicated that the 9-in. thick insulation with a ⅛-in. thick support fin would give the minimum net heat loss.

To keep the liner concentric as it expands radially, forks are provided along the periphery of the support fins that fit into slots in the outer casing. This arrangement allows radial expansion to take place equally in all directions.

Gas passage piping was assembled by a fairly simple procedure. First, each section of liner was insulated with the diatomaceous silica blocks, each of the three layers being bound in place, and the top layer finished with asbestos cement. Then the insulated liner was inserted into a section of the outer casing and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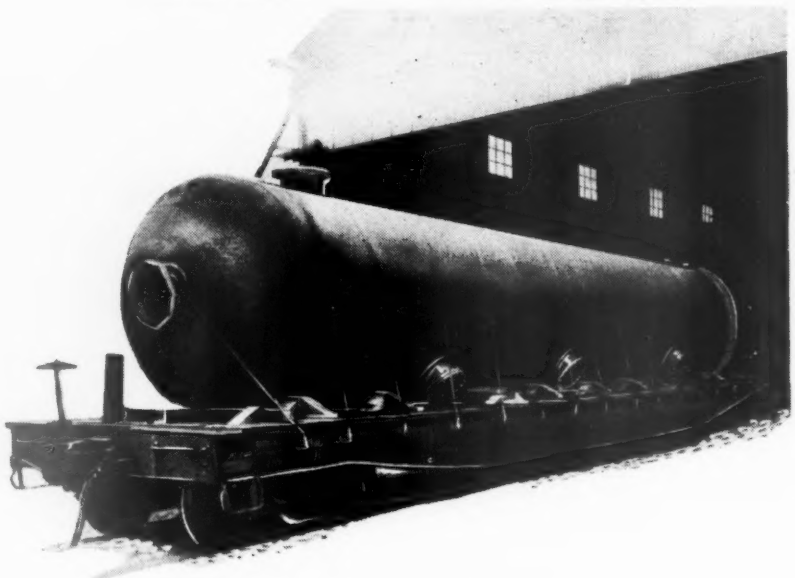

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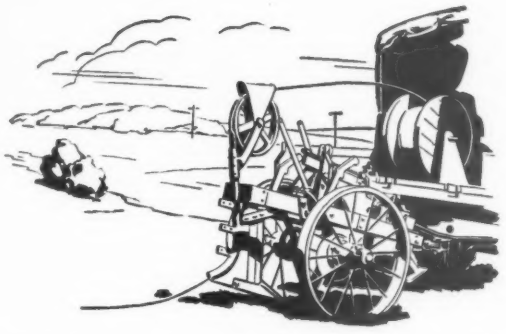
# A GREAT *NEW* DOW DEVELOPMENT!



Here's important corrosion protection news for you. It's GALVO-LINE, a revolutionary new type of magnesium anode developed by Dow.

GALVO-LINE is a flexible, continuous, magnesium ribbon anode, cored over its entire length to prevent segregation and provide lasting electrical contact. It's the most powerful of the magnesium galvanic anodes—develops three to seven times more current flow per pound of anode metal installed. With GALVO-LINE, current requirements are at a minimum because the current source is a *line* rather than a point—current is distributed more uniformly and utilized more efficiently at the protected structure.

But that's not all. Look at the picture above and you'll see how GALVO-LINE is installed simply, quickly, and at considerably less cost than conventional anodes. For pipe lines for example, it can be installed mechanically by means of a truck or tractor-driven wire-laying plow fed from a reel of GALVO-LINE mounted on the plow or truck.

GALVO-LINE is versatile, too! It makes the magnesium anode practical for use in relatively high resistance soils. In low resistance environments it exerts a powerful polarizing action which tames corrosion quickly . . . paves the way for a smaller, cheaper, long-term installation. And it's flexible . . . GALVO-LINE can be bent and formed to conform to the geometrical requirements of a variety of different applications.

***Get the facts . . . write to Dow.***

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# FREE AIR?

## ...NOT ON YOUR LIFE!!

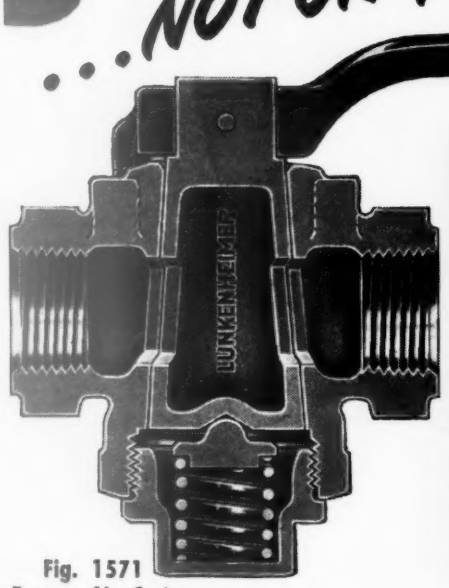

Fig. 1571
Bronze Air Cock

COMPRESSED AIR IS A VALUABLE TOOL *but costly if wasted!*

SAVE IT with LUNKENHEIMER AIR DEVICES

That h-i-s-s-s-s-s you may hear around your air lines means there's a villain loose in your plant. Costly compressed air is escaping, costing you money by the minute. But, you say . . . "it's only a pinhole, can't amount to much." Look at the chart below.

**A SMALL LEAK MAY COST YOU AS MUCH AS $5.82 A MONTH**

| AREA OF LEAK | AIR | |
|---|---|---|
| Diameter Inches | Number of cubic feet per month at 75 lb. pressure | Total cost of waste per month 11c per 1000 cubic feet |
| 1/4" | 3,366,990 | $ 370.37 |
| 1/8" | 824,570 | $ 90.70 |
| 1/16" | 213,000 | $ 23.43 |
| 1/32" | 52,910 | $ 5.82 |

Check your plant . . . compressed air leaks mean that good dollars are "gone with the wind." Replace leaky or defective air devices with LUNKENHEIMER Air Cocks, Valves, Nozzles. Designed for air line service, LUNKENHEIMER Air Devices seat tight and stay tight, requiring minimum maintenance for long, efficient service life. Your Lunkenheimer Distributor has a stock of these devices and fittings. *Write for Circular No. 587 and enlarged copy of air leak chart, suitable for posting.*

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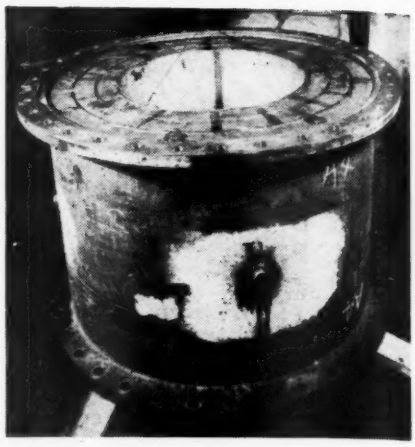

**A 4-ft section of the stainless steel liner of the gas passage piping after insertion in the outer rolled steel casing.**

the various sections of the casing were bolted together. To allow for insertion of the insulated liner into 90-deg elbows, the elbows were split into two 45-deg elbows and the liners in turn were split in half again.

When the curved turbine cylinder inlet sections of the gas passage piping were constructed, the outer casings for these sections were split in half and were bolted together over the insulated liner, after the insulation was applied to the liner.

● **Other insulation.** Other than the combustion gas passage piping, all parts operating at elevated temperatures are insulated externally. The outlet section of the axial flow compressor, where the compressed air leaves at 365 F, is insulated with 2-in. thick blocks of 85 per cent Magnesia. The rest of the compressor does not require insulation. A 24-in. diam pipe with three expansion joints takes the compressed air from the compressor to the heat exchanger. This line is insulated with 2-½-in. thick blocks of 85 per cent Magnesia.

The air inlet side of the heat exchanger, which operates at a temperature of 365 F, is insulated with one layer of 2-½-in, thick blocks of 85 per cent Magnesia. The outlet side, which operates at a temperature of 750 F, is covered with an inner layer of diatomaceous silica block, 2 in. thick, and an outer layer of 2-in. thick 85 per cent Magnesia block.

Except for the inlet sections, which are insulated internally, both turbines were insulated with diatomaceous silica in thicknesses ranging from 4 to 5 in. depending upon the operating temperature in the particular section. Temperatures in the turbines range from 1500 F at the inlet to 1025 F at the exhaust.

The turbine exhaust lines and the exhaust header, which carry the exhaust gases at 1025 F from the turbines to the heat exchanger, are insulated with a 2½-in. thick inner layer of diatomaceous silica and an outer layer of 2-in. thick 85 per cent Magnesia.

The experience and data gained in operating this unit will be invaluable in the future design of gas turbine plants.

★ ★ ★

# new and improved machinery and equipment

A REGULAR FEATURE
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THE Petroleum Engineer
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## (1) Bronze gage valves

A new line of 150 psi S P bronze gate valves has been announced by The Lunkenheimer Company. Designed to meet specific needs and preferences of valve users, the new valves are made in three types: Fig. 2150, where the flexibility of the double disk valve is desired; Fig. 2151, for use where the solid disk is an advantage, as in food processing plants and handling gummy substances; and Fig. 2153, a non-rising stem type for use where head room is restricted.

All valves are equipped with the exclusive Lunkenheimer patented alloy stems. This stem material has shown remarkable resistance to wear, both in tests and field use, according to the manufacturer and minimizes stem thread failures.

The three types of valves in the new line are largely interchangeable. The same body is used in Figs. 2150, 2151, and 2153, rquiring only an interchange of trimmings to convert from one type to another. Screw end valves are rated at 150 psi S. P.—300 psi W.O.G.; flange end valves at 150 psi S. P.—225 psi W.O.G.

Among the features claimed for the new valves are: A deep stuffingbox with extra long threads and a hexagon head gland to permit use of wrench; fully machined repacking seats so that the valve may be repacked under pressure; heavy body and bonnet; and "stay-on" disks that cannot fall off the stem.

## (2) Drilling rig

Extending the range of its drilling equipment for light drilling and workover jobs, The National Supply Company has developed a new, highly portable Ideal Type T-25 Consolidated Rig. This rig, powered by one or two engines with a maximum total input of 250 hp, has a nominal depth rating of 4000 ft with 4½-in. drill pipe. It is also well suited for workover jobs to 10,000 ft with 2½-in. tubing, hoisting speed being comparable to drilling practice.

The outstanding basic design feature of this rig is a Twin Disc torque converter, a new development in fluid power transmission. It is built into the drawworks transmission instead of being conventionally mounted on the engine. This permits using a wide range of engines by merely changing the size of the engine drive sprocket. Combined with a 3-speed transmission, this gives high flexibility and permits operating the torque converter in efficient range at all times.

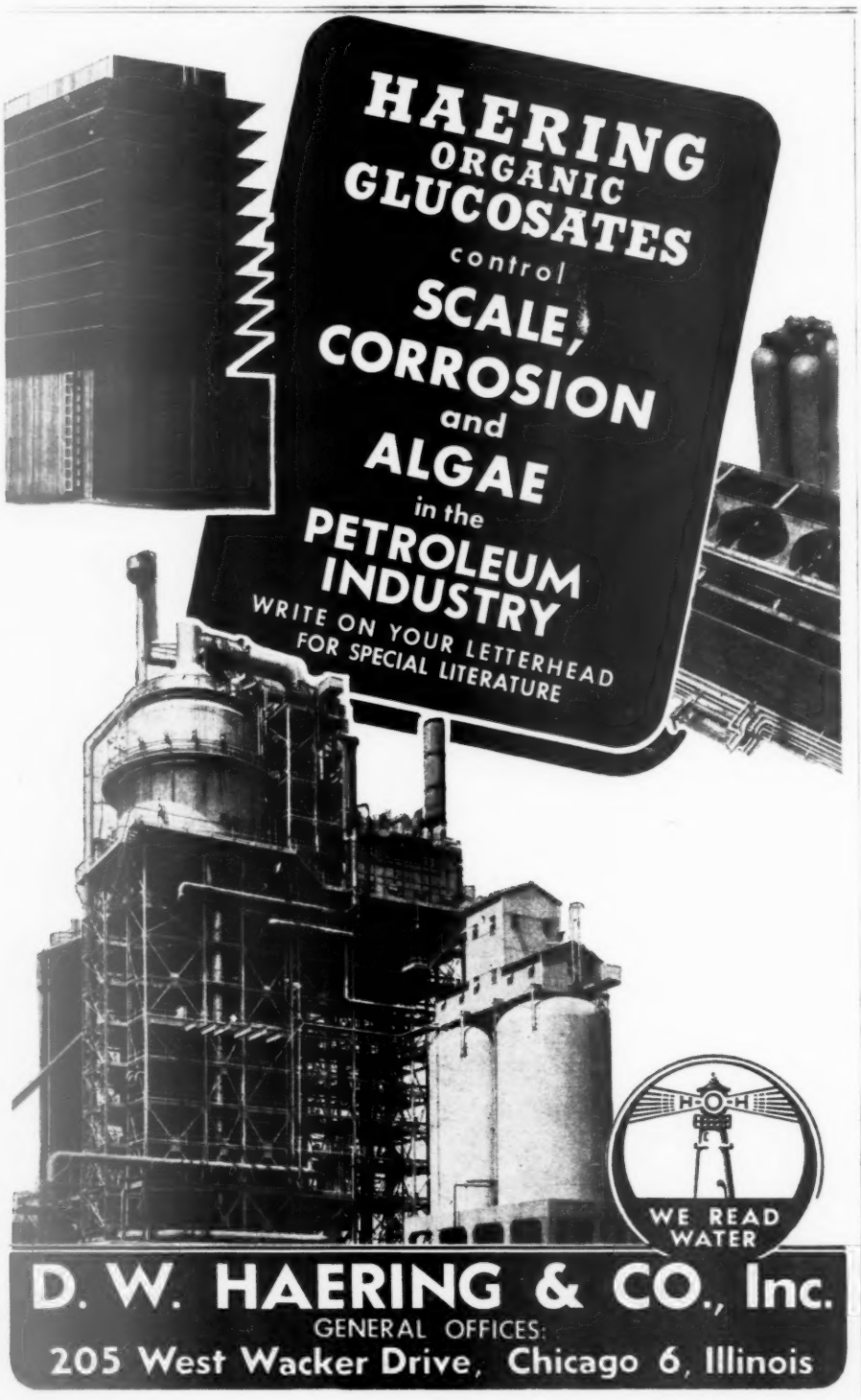
Other features of the T-25 rig are the Fawick air-operated clutches on the main drum and rotary drives, and Fawick Airflex inertia brake. The brake is used to stop rotating parts when making speed changes. This brake is interlocked with the engine throttle to prevent applying engine power when the inertia brake is engaged.

NEW EQUIPMENT

### (3) Air-Pak

The Scott Air-Pak, manufactured by Scott Aviation Corporation, Safety Equipment Division, fits a wide range of uses varying from fire-fighting in smoke to maintenance work in carbon monoxide gas. The Air-Pak is self-contained breathing equipment that delivers fresh, cool air to its wearer through a demand type regulator, and is thus essential to safety and efficiency where men must work in atmospheres of smoke, toxic gases, heat, or those deficient in oxygen. The air supply is carried in a strong ICC approved, light-weight cylinder. No chemicals are used and there is no breathing of stale air. Every breath is a fresh breath and is delivered in exacting the amount and rate "demanded" by the inhalation of the wearer. Breathing is completely independent of the surrounding atmospheres. The Air-Pak uses air exclusively, not oxygen, so that it may be operated with safety in atmospheres containing heavy concentrations of petroleum vapors, where the use of oxygen would be an added hazard.

According to the manufacturer, its use has permitted new methods of fire-fighting, resulting in lower water and fire damage, with greater safety to personnel. Its use in industry has permitted lower cost maintenance with greater personal safety, allowing repairs in heat or toxic gases with a minimum of shut down time.




### (4) Fuel oil meter

Variable mounting arrangements, forged steel flanges and choice of counters are features of the new 60 gpm T-6 truck meter now being manufactured for fuel oil tank wagons and rural service trucks by Smith Meter Company.

Numerous mounting arrangements are possible from four basic positions. The meter can be changed from right to left hand or left to right hand. Different types of counters are available with small or large numerals, set-stop mechanisms, ticket printers, totalizers. Purchaser is thus able to assemble components to fit his installation needs. Forged steel flanges allow a choice of using screwed pipe connections or of having tubing lines welded directly to flanges.

Meter employs 1½-in. pipe size. Flow is 60 gpm, which exactly fits requirements of most pumps. The company also manufactures 100 and 150 gpm truck meters. All three operate on the Smith rotary principle.

### (5) Mud pump liners

With the most modern honing machines now installed and in operation in the company's plant, MacClatchie Manufacturing Company has announced the production of precision honed mud pump liners. This will result in producing a liner that will have a true concentric bore from end to end, it is stated. This new pump liner, which will be available in all sizes and designs, will be manufactured with far more precision than heretofore making it an even finer product than their present liner now being used throughout the world, officials of the company state.

### (6) 45-Ton swivel

A new 45-ton swivel manufactured by the Guiberson Corporation is now being offered to the industry. Incorporating several distinctive features, the new product has been designed to complete a unitized drilling string of Guiberson tools, according to Al Pranger, company sales manager. A complete Guiberson "hook-up," consisting of block and hook, swivel, kelly, and drilling head, is now available for drilling, work-overs, and clean-out work using reverse circulation, he stated. Guiberson officials especially recommend this drilling string as being ideal for use with short derricks and portable rigs.

"Outstanding in the new swivel is its entirely new packing design," Pranger stated. "The washpipe is full-floating, rotating between two independent packing glands. This arrangement literally cuts wear on the washpipe in half be-

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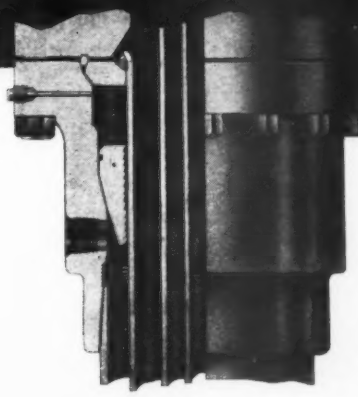
- ✓ —PRESSURE EQUALIZATION
- ✓ —FIRE

When you hook-up with RECTORHEAD you can be sure your well investment is safe. This "RING OF STEEL" seal, provided by the patented Rector welding ring, a good weld (which is easy to make on RECTORHEADS) plus the API ring gasket, is as strong and permanently leak-proof as the pipe you use.

The RECTORHEAD "RING OF STEEL" seal will not deteriorate . . . never requires changing . . . won't freeze . . . won't burn out . . . withstands anti-corrosion chemicals . . . protects against pressure equalization. IT'S PERMANENT.

No special welding skill or equipment are required to obtain the RECTORHEAD "RING OF STEEL" seal. It can be made on ANY GRADE OF PIPE, every time, in one hour of less. Weld or welding ring are never subjected to flange-bolt strain or pressure.

Make sure your wells are safe by installing Rectorhead Casing and Tubing heads with their "RING OF STEEL" between strings of casing.



*RECTORHEAD casing and tubing heads are available in 2000 to 15,000 test pressures. Casing heads are available with slip or mandrel suspension; flanged or threaded bottoms; flanged or threaded side outlets. Three types of tubing head hangers are interchangeable in tubing head bodies.*

**RECTOR WELL EQUIPMENT CO., Inc.**
**FORT WORTH, TEXAS**

Fort Worth Plant . . . . . 1100 N. Commerce St.
Houston Plant . . . . . 2215 Commerce St.

*REPRESENTATIVES IN ALL ACTIVE FIELDS*

RECTOR

RECTORHEAD

ASSOCIATION OF WELL HEAD EQUIPMENT MANUFACTURERS CERTIFIED

MAKING THE OIL INDUSTRY SAFER!

# This Tube has more

# than 9 lives!

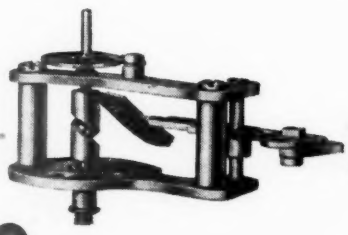
When ordinary pressure gages are used on corrosive sour oil or gas, they last only 5 to 6 weeks. That's what one company* found. Then they tried Helicoid gages with K-Monel tubes.

After 55 weeks, they were removed for inspection. There were no signs of corrosion. The gages tested accurate and were put back in service.

This is a typical case proving how money is saved by using Helicoid Gages. There are countless other examples.

For better gage value for any kind of service, insist on Helicoid—the gage of enduring accuracy.

*Name on request



*Only Helicoid Pressure Gages have the Helicoid Movement*

ACCO

HELICOID GAGE DIVISION
AMERICAN CHAIN & CABLE
Bridgeport 2, Connecticut

TRADE MARK


cause rotation is in either or both packings." Pranger pointed out that the ease with which an operator may replace the assembly is an added advantage. He said replacements are made without moving the gooseneck or hose and that no special tools are required.

The Guiberson sales manager announced that an extra washpipe and gland assembly will be included with each swivel. He said that operators would thus be able to quickly and easily replace an entire assembly with the spare when necessary, eliminating any need to consider the maintenance of a supply of individual parts. Pranger stated that Guiberson has established a service to completely restore worn assemblies at the factory, returning to the operator a spare with new parts replacing worn sections. This plan will insure constant availability of a "factory new" spare, according to Pranger.

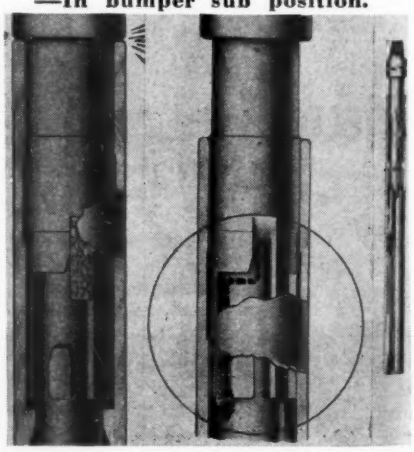
### (7) Bumper sub safety joint

A new and versatile tool for drill string protection is the Shaffer Bumper Safety Joint, a tool that incorporates both a bumper sub and safety joint into one unit, and both types of applications provides improvements over one-purpose tools, according to the manufacturer.

By using a new type of spring arrangement, the tool is assembled with a preloaded spring compression that holds the bumper safety joint locked in an open position at all times and under all drilling conditions until it is desired to strike a downward blow. To operate the bumper safety joint a weight equivalent to approximately 2000 ft of drill pipe is lowered onto the tool. This weight actuates a foolproof tripping mechanism that automatically releases, allows the weight of the pipe to strike a heavy downward blow, and then automatically re-cocks itself after the blow has been struck. Blows can be struck repeatedly and continually as long as desired by simply raising and lowering the drill string. Also, the weight necessary to trip the tool can be varied, if desired, when assembling the tool.

As a bumper sub, this new device has certain features. The tool remains locked in the open position at all times until the required weight of drill pipe is lowered against it. When drilling with drill collar weight, as most of today's wells are,

**Left—Tool in locked position; center—As a safety joint; right —In bumper sub position.**



the tool can be placed immediately above the drill collars to provide maximum protection to the drill string. Should it be desired to apply additional weight during the drilling operations, the weight of as much as 1800 or 1900 ft of drill pipe can be added to the bit without tripping the tool, thus providing a substantial safety factor to meet various drilling requirements. As the tool remains in locked position during all normal operations, there is no "working" of the joint —therefore no wear on the packing unit or other operating parts. This greatly lengthens the life of the tool and insures minimum maintenance and wear. Yet whenever a solid downward blow is desired for loosening stuck pipe, breaking through bridges, etc., it is only necessary to lower the required amount of weight onto the tool, whereupon the blow is automatically struck—and can be struck repeatedly.

In addition to its use as a bumper sub, this new Shaffer development also incorporates a safety joint feature that has a number of valuable features. To operate the safety joint, reverse torque is placed in the drill string and then the required amount of weight to actuate the bumper sub is placed on the tool. The unlocking of the bumper sub, coupled with the reverse torque in the string, rotates the driving lugs into an unlocking slot similar to that of a "J" tool. Then by simply lifting the drill string, the top half of the tool is removed along with the drill string, leaving the lower half in the hole with the drill collars.

One important consideration is that the safety joint in this tool is the strongest joint in the string. Until reverse torque, coupled with the weight of at least 2000 ft of drill pipe, is placed on the tool the safety joint will not unlock —yet the safety joint releases readily when the prescribed operations are performed. Because of this important safety feature, continuous reverse rotation can be performed, if necessary, with applied weight of not only the drill collars but also that of the drill string up to almost 2000 ft of pipe. In other words, so long as the actual tripping weight of approximately 2000 ft of drill pipe is not placed on the tool, it remains in the locked position and the joint is stronger than any of the other joints in the drill string; but as soon as the proper amount of weight is placed on the tool, coupled with reverse torque, the safety joint releases quickly and easily.

### (8) Diesel engine

The Waukesha Motor Company announces the Model 6-LRD diesel engine, adaptable to oil well drilling.

The stripped engine is rated at 300 hp at 900 rpm, or as a complete radiator cooled power unit, at 281 hp at the same speed. Maximum output of the stripped engine is given as 330 hp at 1050 rpm, and of the power unit, 301 hp at 1050 rpm. The engine is $8\frac{1}{2} \times 8\frac{1}{2}$ bore and stroke, six cylinders, with a displacement of 2894 in.

The diesel engine, Model 6-LRD, although it occupies approximately the

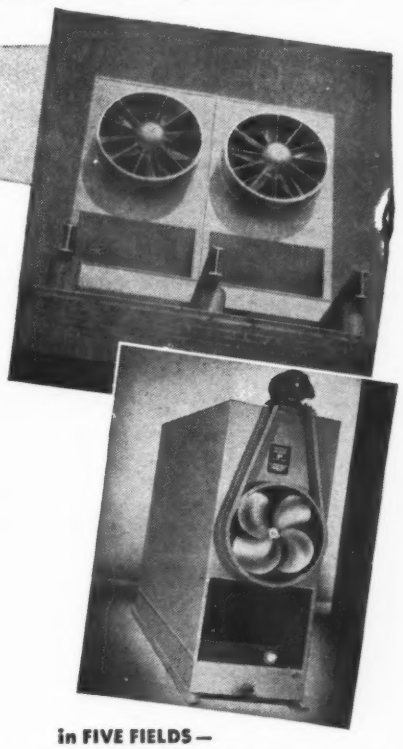

It's NOT TOO LATE!

**Consult PRITCHARD Now for your Cooling Tower Repairs**

There is still time for the Equipment Division of J. F. Pritchard & Co. to repair and make mechanical improvements on your present cooling tower — *regardless of make.* Without any obligation, Pritchard Field Engineers will survey your tower and submit comprehensive recommendations for the rehabilitation of your structure and, if advisable, suggestions for the replacement of the mechanical fan drives—*on any make of tower.*

The induced draft mechanical assembly pictured to the left is the famous Pritchard patented SEALDFLOW Drive which mounts motor and gears vertically on the fan shaft. This unitized drive, as well as the two induced draft towers described below, is available in a range of sizes for new towers or as a replacement on your existing tower. Consult the EQUIPMENT DIVISION at once for further details.

Small and Medium Capacity
**INDUCED DRAFT**
Towers Shipped from Stock



Either horizontal or vertical air flow, with outstandingly efficient "Lifetime" fans ... the all-Monel fan with permanently lubricated, slow-speed direct drive motor built right into the hub! No gears, no belts, no couplings, no corrosion problems. Maintenance is nil! Other advanced mechanical and structural features throughout.

**ASK FOR BULLETIN 1-19-88**

Metal "packaged" cooling towers for indoor or outdoor installation, designed for minimum maintenance. Completely assembled with fans and motors, ready to put in service. Copper-bearing steel models shipped from stock; aluminum, Monel, stainless steel, etc., also available.

**ASK FOR BULLETIN 5-6-80**

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in FIVE FIELDS — Serving the CHEMICAL, GAS, PETROLEUM and POWER industries as well as providing EQUIPMENT for all industries.

EQUIPMENT DIVISION 908 Grand Ave., Kansas City 6, Mo.

See Sweet Files, Chemical Engineering Catalog, Refinery Catalog, etc. for additional information on Pritchard engineering and construction services and equipment.

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ENGINEERS • CONSTRUCTORS • MANUFACTURERS
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LITTLE ROCK • RICHMOND • OMAHA • MEMPHIS • BALTIMORE • CEDAR RAPIDS • AMARILLO
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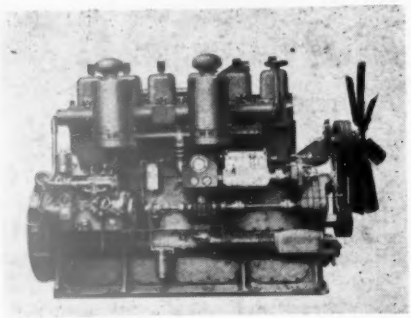
same space as its gas engine counterpart, is entirely new from the crankshaft up. A large seven-bearing 5½-in. graphitic steel crankshaft is used, which is heat-treated and hardened to give crank pin and main journal hardness of 75-90 scleroscope index. The cylinder block is a husky one-piece casting into which are inserted the six hardened wet cylinder sleeves held in place by individual cylinder heads and head gaskets at the top, and the usual synthetic plastic rings at the base. Cylinders are of a special hardened alloy which test 400 Brinell.



### (9) Test gage

Helicoid Gage Division, American Chain and Cable Company, Inc., announces a standard test gage for use with Reid vapor test bombs. It may also be used for any service where an accurate, portable test gage is required.

Accuracy of the new Reid vapor test gage is guaranteed to within ½ of 1 per cent. It has the stainless Helicoid precision movement. Dial size is 4½ in. and made of white laminated Phenol.

The flangeless case is Acaloy and is weatherproof with an external micrometer pointer adjuster. The snap ring is stainless steel (18-8) with neoprene gasket. The long, stainless steel (18-8) shank has a square, and ¼-in. male pipe thread.

### (10) Sonic indicator

A new, sonic indicator that is said to remove guesswork about down-the-hole conditions has been announced by McCullough Tool Company. This new indicator, an electronic device, has been incorporated as an integral part of the McCullough electrical firing gun perforator. It is invaluable for accurately locating collars, liner tops, fluid levels, and well bottoms, instantly and accurately as the gun meets them and in ascertaining movement of the gun or speed of its movement by sound, the manufacturer asserts.

When used with the new McCullough supersensitive electronic weight indicator, the instrument provides an audible and visible check giving positive information at all times on gun location and movement in relation to line speed.

The device operates as follows:

Finder wires protrude from the electrical firing top assembly of the McCullough gun perforator. As the gun perforator is lowered into the well these finder wires scrape along the inside of the casing. The sound produced is transmitted through the radio panel in the McCullough electric truck unit where the operator listens for identifying sounds. Every down-the-hole condition makes its own distinctive sound, every change in gun movement signals itself by change of sound. When the gun is fired, the detonation can be heard by the operator eliminating all guesswork in this respect.

Built in the center of the great Texas oil fields, HOBBS Pole Trailers are engineered to get the job done economically where the going is toughest. And HOBBS Pole Trailers can take punishment too. Ask anyone who uses Hobbs equipment.

**HOBBS PIPE LINE SPECIAL (PLS)**
—is designed for use with trucks not equipped with platform body. Both the OFS and PLS are engineered especially for handling pipe, poles, and other long material.

**HOBBS OIL FIELD SPECIAL (OFS)**
—shown in above photo, for general utility work — to be used behind trucks equipped with oil field bodies.

**HOBBS WT-4 TANDEM AXLE DREADNAUGHT POLE TRAILER**
— can be used as conventional pole trailer, a 4-wheel wagon, or wagon behind truck or tractor. Separately mounted axles; adjustable bail type tongue. Capacity 60,000 lbs. on truck and trailer; 30,000 lbs. on trailer alone.

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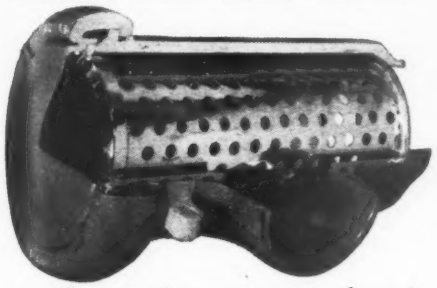
### (11) Pipe line strainer

Thornhill-Craver Company has announced the new Unibolt pipe line strainer.

The cut-away view shown herewith illustrates the mechanical design of the strainer. A Unibolt coupling with blank-



ing plug permits easy entry to the unit for cleaning the strainer element. Releasing of only two bolts is required, and the screen may be easily removed from the strainer housing for cleaning.

### (12) Four-wheel scrapers

New, improved cable-controlled S-type four-wheel scrapers, manufactured by Bucyrus-Erie Company, are now available. Thoroughly tested in the field, these units are said to combine brand new performance features with characteristics that have proved successful through years of experience in the production of earth-moving equipment. Models included in this new series of scrapers are: the S-46 (4 cu yd struck capacity), S-68 (6-cu yd struck capacity), S-91 (8-cu yd struck capacity), and the S-113 (10-cu yd struck capacity). These, plus the 15-cu yd B-170 and the 22-cu yd B-250, make up the Bucyrus-Erie four-wheel scraper line.

Increased maneuverability is one of the principal features stressed in the design of these improved scrapers.

### (13) High pressure gage

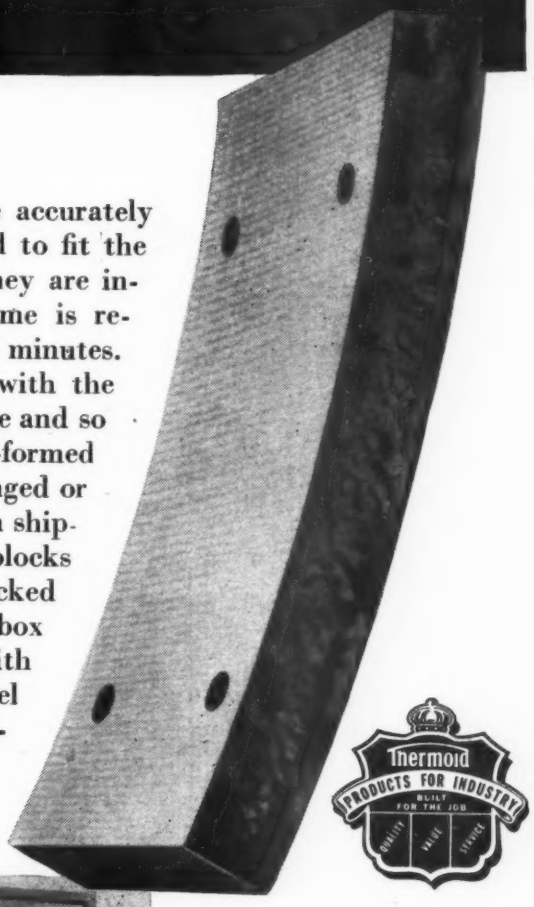
A new liquid level gage capable of withstanding tremendously high pressures has been developed by the Jerguson Gage and Valve Company for use in laboratory and process work where engineers are working with pressures higher than the capacity of ordinary gages.

The gage is designed for pressures of 10,000 psi or higher, depending upon the safety factor requirements, said James A. Ford, sales manager, in announcing the development of this new gage. He also pointed out that the gage has been tested up to 20,000 psi.

Th new Jerguson high pressure gage has greater strength than any other gage of its type due to its unusual construction, according to the manufacturer. The chamber and covers are machined from bar steel stock, and the covers have a series of ½-in. ports through which the liquid level, color, or density is viewed. The glass is 11/16-in. thick tempered Pyrex, and O-Ring gaskets confine the pressure on the glass to the area of ½-in. diam circles.

The gage is built in standard lengths up to approximately 6 ft. It is also available in stainless steel or other special metals to resist corrosive conditions.


Thermoid
Brake Blocks
for ALL Oil Field Drawworks



Built to fit . . .

Thermoid Blocks are accurately formed and jig drilled to fit the machine for which they are intended . . . relining time is reduced to a matter of minutes. Each set is packed with the blocks stacked on edge and so protected that the pre-formed radius cannot be changed or the blocks distorted in shipment. Only enough blocks for one band are packed in a container. Each box is clearly marked with the make and model number of the equipment to be serviced.

Thermoid
PRODUCTS FOR INDUSTRY
BUILT FOR THE JOB
QUALITY VALUE SERVICE

No matter what make or model drawworks you use, there is a "Packaged Set" of Thermoid Oil Field Brake Blocks manufactured specifically for your machine. These blocks are designed to provide top operating efficiency and long life, even under the most severe service conditions.

Your oil field supply house will gladly help you with your service requirements.

Thermoid
Thermoid Company, Trenton, N.J., U.S.A.
Automotive • Industrial • Oil Field • Textile

# 58%

Technically speaking, the illustration is incorrect because, under average producing conditions, that 58% of your oil will never reach the surface, much less a stock tank.

From 291 of the best engineered fields in the United States, only 22% of the oil in place is being recovered through primary means alone. Add this figure to the 20% residual not recoverable through any known method. That leaves 58% of your oil in the reservoir, to be or not to be produced as secondary oil.

Where do rule-of-thumb methods of production end and plans for *complete engineered control* of a reservoir begin? Back on the derrick floor when the first cores of a producing formation are taken.

An accurate analysis of these cores is the only method of obtaining *all basic data* necessary for predicting proper completion depths and techniques, well spacing patterns, and study of sand conditions prior to establishing an optimum primary and secondary recovery program.

Core Laboratories, Inc., the only organization of its type in the world participating in every phase of petroleum reservoir engineering, has authored this first chapter in hundreds of reservoir success stories. On Location Core Analysis, through the use of portable field laboratories, and Off Location Core Analysis with On Location Results (Frozen Cores) make these services economically feasible and available to every company and independent operator within the United States.

There is a Core Lab man near you. Would the possible recovery of 58% more oil make a visit from him worthwhile?

*"If it's worth coring, it's worth analyzing"*

CORE

PETROLEUM RESERVOIR

# trade literature

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### (14) Lubricated plug valves

American Car and Foundry Company, Valve Department, has issued a booklet on the ACF full pipe area lubricated plug valves. These valves are made of steel, semi-steel, bronze, and other metals, and are used in services handling acids, caustics, chemicals, oil, water, air, gas, etc.

### (15) Rotary drilling equipment

Oil Well Supply Company has released a 12-page booklet, No. 2C-1047, entitled "Oilwell Rotaries." Included are the several types of rotaries manufactured by this company. The booklet is of especial interest because it describes many design features that are not generally known to the industry.

### (16) Power rig

The complete story of the Ideco PR-1050 Power Rig is given in Bulletin PR-1050-48, issued by International Derrick and Equipment Company. This rig is 100 per cent air controlled, which, the manufacturer asserts, makes for smooth, fast, and flexible operation at lower drilling cost.

### (17) Equipment corrosion

An interesting and revealing pamphlet on corrosion of production and drilling equipment has been released by the Amercoat Division of American Pipe and Construction Company. This concentrated discussion of a particularly vexing problem defines the various conditions and reactions that cause corrosion, including the presence of hydrogen sulphide and salt water, as well as conditions suitable to the development of hydrolytic and electrolytic phenomena. It lists in tabular form the types of corrosion to which each item of production or drilling equipment may be exposed, and describes the specific coating that has been developed to combat the corrosion effect.

### (18) Hydraulic pumping units

Two bulletins issued by W. C. Norris, Manufacturer, describe types of hydraulic pumping units on which the company is now in production. Bulletin 35 describes the "Hyd" Pumper, a hydraulic rod line pumper for any number of wells with one power unit. Bulletin 36 describes the weight counterbalance type pumping unit, which is manufactured in several models.

### (19) Jet perforating

Welex Jet Services has issued a bulletin describing well perforating by means of high velocity jets rather than bullets. According to the company, high velocity jets resulting from the detonation of shaped charges made from the proper detonating powder are more effective in casing perforating and open-hole shooting than are bullets, for the same reason that jet weapons of World War II proved more effective than bullets in armor-piercing tank destroyers.

### (20) Seismic equipment and services

Century Geophysical Corporation has issued a new catalog in which is illustrated and described the seismic equipment and services that are available to the industry through its organization. Equipment is available for all types of operations—reflection seismograph, refraction seismograph, dip shooting, continuous profile and three dimensional surveys.

### (21) Clad steels

Lukens Steel Company has issued a bulletin called "Pioneer in Clad Steels." This booklet tells of the development of this product from the first Lukens clad steel in 1930, Nickel-Clad, to the present clad steel line, which includes Nickel-Clad, Stainless-Clad, Inconel-Clad, and Monel-Clad.

Another bulletin released by the same company is entitled "A Visit to Lukens." In picture and story the reader is taken through the plants of Lukens Steel Company and its subsidiaries, By-Products Steel Corporation and Lukenweld, Inc.

### (22) Application of diesel engines

With a new 24-page issue recently off the press, "The Dependable Diesel" enters its fourth year of publication. Published by the Cummins Engine Company, Inc., the current issue of this magazine for power users contains more than 40 pictures showing Cummins diesels used in a wide range of applications.

Now being distributed by Cummins dealers, this issue features stories about Cummins diesels used in the automotive, petroleum, construction, mining, marine, and other industrial fields.

### (23) Mud mixing machine

The Commercial Mud Mixing Machine Company has issued a 4-page bulletin that contains descriptive data on a new type hopper, feed and mixing chamber with operational features. Specification drawings are included.

### (24) Wellhead equipment

Bulletin No. 313A, newly issued by The National Supply Company, catalogs National Type B pressure pack wellhead equipment. Features of construction are described and fully illustrated with cross-sectional views and pictures of individual parts. These include casing flanges and spools, tubing spools, safety hold-down flanges, slip weld flanges, slips, mandrel type casing hangers, bit pilots, bonnets, and interchangeable tubing hangers. Special attention is given to seals and packing. Six types of assemblies are shown in half-section and followed by 22 pages tabulating various sizes and part numbers.

### (25) Portable power and light

How electricity is made available anywhere with portable electric generating plants that can be carried, wheeled, or trucked to the job is shown in a new two-color folder recently released by D. W. Onan and Sons, Inc. Onan electric plants, made portable by means of carrying handles and frames and rubber-tired, two-wheeled dollies, are pictured in models ranging from 350 watts to 3000 watts in 115-volt, 60-cycle, alternating current; 115-volt, direct current models are also described in 600 to 5000 watt range. These portable models are powered by Onan air-cooled, 4-cycle, gasoline engines.

Water-cooled, large-capacity electric plants for trailer, skid or truck mounting, in sizes 2000 to 35,000 watts a-c, or 3500 to 15,000 watt d-c are also shown.

### (26) Motor vehicle laws

The 1948 truck and trailer size and weight restrictions booklet, which includes an up-to-date listing of laws affecting size and weight restrictions for commercial vehicles, is off the press and ready for distribution by The Four Wheel Drive Auto Company. The new booklet covers all the 48 states and explains graphically the differences between the motor vehicle laws of the several states.

### (27) Latest issue of production road

The latest issue of *Production Road*, a magazine published by the Twin Disc Clutch Company, pays a pictorial tribute to the sales engineers, dealers, and service men who represent the Twin Disc Clutch Company throughout the United States and Canada. It pictures their buildings, repair facilities, and stocks of parts maintained.

Designated the "Sales and Service Issue," the 20-page magazine describes the company's new production methods of service parts and the new branch sales engineering office recently opened in Los Angeles. It also describes the Twin Disc line of clutches, hydraulic drives, and marine gears.

### (28) Study of oil purification

Volume 4 No. 1 of "Clean Oil," a quarterly publication of Honan-Crane Corporation, just off the press, presents an unusually interesting case history of oil purification and how it solved several major problems for a Canadian plant producing styrene and other chemicals derived from petroleum crude. This case history tells how Honan-Crane purifiers, installed on 43 engines, have extended engine overhaul periods from 5,000 to 10,000 or more hours, cutting the labor bill and down-time for engines in half. Parts replacement costs also have been greatly reduced. The total purification cost figures about $1 per week per engine.

To Reduce
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Costs
Specify Pacific
Precision Built
Type WY
Vertical
Centrifugal
Pumps
SAVE BUILDING COSTS
That tight corner may be utilized without expensive alterations to the building. That new pump house may be smaller and less costly than for horizontal pumps of equal capacity.
GPM CAPACITY
FLR. SPACE IN INCHES
To - 200
18 x 18
200 to 600
24 x 24
600 to 1000
28 x 28
SAVE COST OF ELEVATING SUPPLY TANKS FOR NPSH
All a Type WY pump asks you to supply is 1 foot or less NPSH at the suction flange of the pump.
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HUNTINGTON PARK, CALIF.
One of the Dresser Industries
Export Office Channin Bldg.
122 E. 42nd St., New York
Offices in all Principal Cities
V-1

### (29) Inverted multuplex pumps

A new 12-page catalog, Data Sheet 67, issued by The Aldrich Pump Company, contains complete details on Aldrich inverted multuplex pumps including the Aldrich triplex, quintuplex, septuplex, and nonuplex. It includes numerous photographs, pump dimension drawings, and easy-to-read pump selection charts for selecting the type and size pump required for varying operations.

Of particular interest to users of more than one high pressure pump are two sections dealing with interchangeability of parts on 6-in., 7-in., 7½-in., and 8-in. stroke multuplex pumps.

### (30) Electric weld oil country goods

"Republic Electric Weld Oil Country Goods" is the title of a new 8-page, 2-color, booklet issued by Republic Steel Corporation. The booklet gives the highlights of the manufacture of Republic Electric Resistance Weld Pipe as the process affects the quality of the product. It points out the advantages of the electric weld process for oil country line pipe, casing, and tubing.

### (31) Geared motor power

The use of geared motor power in driving machinery and the presentation of latest electrical motor models are dramatically shown in a multi-colored 16-page bulletin issued by the builders of U. S. Motors.

Advantages of using hardened gears and pinions to obtain greatest wear resistance and methods of attaining hardness are described. The bulletin also presents the several latest models of Syncrogears in single, double, and triple reductions and for use in combination with Varidrive units. Sizes range from ¼ to 30 hp. and standard AGMA speeds of 10 to 10,000 rpm.

### (32) Rewinding D-C motors

Recommendations for the rewinding of d-c motors with Dow Corning Silicone Class "H" electrical insulation, are given in a recent release of Dow Corning Corporation. Motors rewound in accordance with such recommendations should have ten times the life and ten times the wet insulation resistance of motors rewound with Class "A" or Class "B" insulation, according to the company.

Use of this new class of exceptionally heat and moisture resistant electrical insulation, however, does not solve all the problems related to d-c equipment. It is still good practice, for example, to remove the field coils from the stator and examine them before rewinding the armature. If visual inspection shows that the insulation is dry, brittle, and cracked, the field coils should be reinsulated.

If failure is obviously due to high temperatures caused by overloads or continuous operation of intermittent rated motors, or to excessive moisture, the best procedure is to rewind the motor with Dow Corning Silicone electrical insulation, it is asserted.

### (33) Pumps for abusive service

Bulletin No. 4711, released by Nagle Pumps, presents the recent developments in a line of horizontal and vertical shaft centrifugal pumps that combine efficiency, simplicity and ruggedness, plus the characteristics needed for the abusive processes in industry. These applications include pumping corrosive or hot liquids and abrasive or heavily laden mixtures.

### (34) Dry-type intake air filters

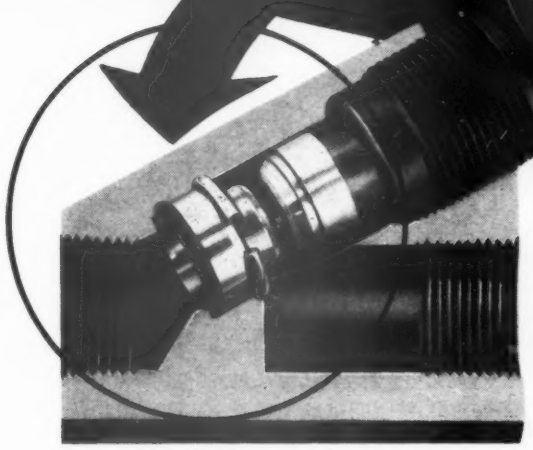
A 2-color, 8-page bulletin describing the complete line of Staynew dry-type intake air filters for all types of air compressors, diesel and gas engines, blowers, motors, and generators is announced by Dollinger Corporation. The various filters described in this bulletin include silencer models, regular dry-type, and breather filters. They range in size from 6 cfm to 8000 cfm in single units. All the filters described in this bulletin feature the original radial finned insert design.

### (35) Testing of welds

Testing of welds in plate, thin sheet, and other sections with the Sperry Supersonic Reflectoscope, using a new angle transmitter, is fully described in Sales Data Sheet 3021, a publication of Sperry Products, Inc.

**For AIR • GAS • WATER & PETROLEUM PRODUCTS**

# THE NEW *Automatic* VALVE USES NO LUBRICANT SEAL



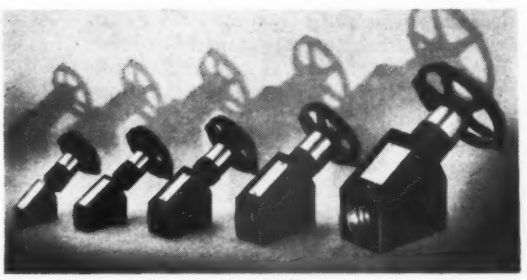
SERIES V

**30° FLOW PASSAGE**

## THE *Greatest* VALVE DEVELOPMENT IN *20* YEARS

***DESIGNED Specifically for Cold Service to 2000# CWP 180° F.***

Grove Seat-Seal Valves represent the most startling development yet perfected in valve design and construction. Through a most unique arrangement, a *soft* pliable synthetic rubber ring is *pressure* sealed over dirt and solid particles, at the moment the metal valve disc is seated on its metal seat ring. As the valve is opened, the flexible rubber ring is *pressure released,* and its elastic resilience ejects any dirt. An unusual feature is the fact that the soft rubber ring is never blown away or damaged, even though the valve is opened and closed many thousands of times. A *full floating* seat ring that aligns itself to a solid non-turning plug and stem unit is employed. The valve closes in the direction of flow so that no working parts are exposed to cutting action or erosion. An encircling cap shields all threaded surfaces from paint, dirt, dust and damage. Sealed-in lifetime lubrication is *zoned* entirely away from the flowing fluid. All working parts are readily replaceable in the field without special tools.



Available in sizes from ½" to 2" Grove *Seat-Seal* Valves embody the same high standards of dependability as the widely used *Grove Regulators.* Like Grove Regulators, these valves will render years of service in hardest usage. Quick replacement of worn parts provides *the equal of a new valve* in a matter of minutes. Request Bulletin 5060.

***As Fully Dependable As The GROVE REGULATOR***

# GROVE *Seat-Seal*

GROVE REGULATOR CO. • 6529 HOLLIS STREET • OAKLAND 8, CALIF.

# running tour with men in the industry

● **Clarence F. Hansen** has been elected president of the recently organized Calmara Oil Company, San Francisco. Calmara is a wholly owned subsidiary of the Richmond Exploration Company, which in turn is a Standard of California subsidiary. The new firm has been set up for the purpose of transporting and selling crude oil from Venezuela.

C. F. Hansen

Hansen has been with Standard since 1920. He became president of American Gilsonite Company, a Standard affiliate, in 1945 and for eight years previous was chief engineer of Standard's manufacturing department.

● **Charles A. Hampton,** a veteran of two world wars and long associated with electronics and communications, has joined the Federal Telephone and Radio Corporation, Clifton, New Jersey, associate of International Telephone and Telegraph Corporation, as sales representative for the mobile radiotelephone division, covering the State of Washington and Northern Idaho.

Hampton, a Lt. Commander in the USNR, at one time operated his own ship-to-shore radio station (KFT) in Everett, Washington, but in 1940 reentered the Navy and was assigned as resident inspector for Navy material in Sunbury, Pennsylvania. In 1945 he was assigned as electronics officer, Bremerton Group, Pacific Reserve Fleet.

A native of Philadelphia, Hampton studied at the University of Pennsylvania, Harvard University, and Massachusetts Institute of Technology.

● **R. W. Miller** and **I. R. Cunningham** were elected members of the board of directors at the annual meeting of the stockholders of the Creole Petroleum Corporation. At the same time announcement was made of the resignation of **R. H. Sherman** as a member of the board.

Miller, who was recently elected a vice president of the company, is in charge of export sales of crude oil and products and coordinates all crude oil purchases and exchanges. Cunningham was appointed comptroller of the company in August, 1945.

● **Curtis R. Holton,** has been named director of industrial relations at Ethyl Corporation, it is announced by Edward L. Shea, president. He will be responsible for employe and industrial relations throughout the company. Holton, who has operated his own office as industrial relations consultant for the last four years, was formerly personnel director in the St. Louis division of the Kroger Company for eight years, and a senior staff member of Industrial Relations Counselors, Inc., for eight years.

● **Edward L. Ghormley,** formerly of California Research Corporation, has joined the staff of George Armistead, Jr., consulting chemical engineer of Washington, D. C., Ghormley, who has recently completed graduate work at Massachusetts Institute of Technology will be engaged in process and design engineering.

● **William K. Whiteford,** president of the British American Oil Company, Ltd., Toronto, Canada, and the British American Oil Producing Company, Tulsa, Oklahoma, was recently elected a director of the Bank of Nova Scotia, one of the 11 national chartered banks in Canada with offices throughout Canada and in Great Britain and the West Indies. Whiteford, who is a native of Los Angeles and a graduate of Stanford University, is active in the American Petroleum Institute and a member of the American Institute of Mining and Metallurgical Engineering.

W. K. Whiteford

● **J. W. Turner** has been named credit manager of Republic Supply Company, Houston, Texas. Turner moved to Houston headquarters from Corpus Christi where he was associated with the Sam E. Wilson Interests. He is a graduate of Oklahoma A. & M. and has spent all his business career in the oil industry. **H. A. McDannald** will assist Turner as assistant credit manager.

J. W. Turner

● **Wayne C. Edmister** of Scarsdale, New York, who supervised process design of the atomic pile (nuclear reactor) at the Brookhaven National Laboratory on Long Island, has been appointed a professor of chemical engineering at Carnegie Institute of Technology, it is announced by Dr. Webster N. Jones, director of the College of Engineering and Science at Carnegie. Edmister, a native of Cleveland, Oklahoma, is senior chemical engineer and assistant director of process development for Hydrocarbon Research, Inc., of New York City, and is adjunct professor of chemical engineering at New York University.

One of the leading men in the field of petroleum engineering and chemistry the new appointee has taught at Illinois Institute of Technology, where he did part of his graduate work, at the evening school of the Standard Oil Company of Indiana, and at N.Y.U.

● **Warren K. Venatta** has been named manager of product control by Oronite Chemical Company, subsidiary of Standard Oil Company of California. In his new position, Venatta will coordinate production availability with requirements.

W. K. Venatta

Venatta joined California Research Corporation, Standard's research subsidiary, in 1939 after his graduation from the University of Wisconsin as a chemical engineer. His work has been principally connected with alkylation, isomerization, and propylene polymerization.

● **John P. Dennis,** assistant traffic manager for The Texas Company for the last six years, has been appointed traffic manager. He succeeds **W. L. Macatee,** who is retiring after 36 years' service with Texaco. Dennis, a native of Preston, Maryland, entered railroad service with the Northern Pacific Railway in 1921 as a clerk in St. Paul, and advanced through various positions to the post of assistant to the vice president of that road. He joined The Texas Company in 1942 as assistant traffic manager.

● **W. E. "Ed" Larson,** sales engineer, McCullough Tool Company, Western Division, toured the Rocky Mountain district after attending the AAPG convention in Denver. He will also visit the new Leduc field in Western Canada near Calgary where McCullough equipment is being used.

● **R. C. Brown** was appointed vice president, director, and manager of Hudson's Bay Oil and Gas Company, Ltd., a Continental subsidiary, following a meeting of Hudson's Bay Oil and Gas Company directors in Winnepeg, Canada. The meeting was attended by L. F. McCollum, president of Continental, and W. H. Ferguson, executive vice president.

R. C. Brown

Brown, whose new headquarters will be in Calgary, has been an employe of Continental Oil Company for nearly 24 years.

● **Rex V. Phelps** has been appointed to the newly created position of manager of the Warren Maritime Corporation, according to **G. L. Brennan,** vice president. Phelps will continue as chief sales engineer for the Liquified Petroleum Gas Division of Warren Petroleum Corporation, of which the maritime corporation is a wholly owned subsidiary.

# 10 GOOD REASONS WHY OPERATORS PREFER

## McCullough
## GUN PERFORATOR SERVICE

1. **MEETS EVERY CONDITION.** Guns fired either electrically or mechanically: guns run on cable, sand line, drill pipe, tubing, or on piano-wire measuring line in extremely high-pressure wells.
2. **SIMULTANEOUS FIRING** under all conditions gives exact spacing of shots, perfect perforation pattern, and saves down-the-hole time.
3. **ACCURATE DEPTH MEASUREMENTS** put the shots right where you order them.
4. **MAXIMUM PENETRATION** of bullets into the formation, as proved repeatedly in competitive field tests.
5. **GUNS TO FIT EVERY CONDITION.** McCullough employs more than 30 different types and sizes of guns.
6. **ALL SIZES OF BULLETS** from $\frac{1}{16}$" dia. up to $\frac{3}{4}$" dia., to fit every possible need.
7. **BURRLESS BULLETS,** giving a completely burr-free hole, eliminating casing scraping, with *no* sacrifice of penetration.
8. **NO LOST TIME.** McCullough's simpler, lighter equipment cuts setting-up and moving-out time, speeds up every job.
9. **EXPERIENCED MEN.** With years of experience behind them, thoroughly-trained McCullough gun-perforating crews do their jobs quickly, efficiently, safely.

**These Are Some of the Reasons Behind the Proven Fact That**

**McCullough**

**PUTS THE SHOTS WHERE THEY COUNT!**

**10** This is a section of a McCullough **90-SHOT GUN** perforating a 15-foot section with 6 holes to the foot, at one run.

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**MISSISSIPPI:** Laurel
**NEW MEXICO:** Hobbs
**KANSAS:** Ulysses
**CALIFORNIA:** Los Angeles, Avenal, Bakersfield, Ventura
**LOUISIANA:** Houma, Lake Charles, New Iberia, Shreveport
**WYOMING:** Casper

EXPORT OFFICE: 30 Rockefeller Plaza, New York 20, N. Y.

● **Paul H. Shepherd,** manager of Oil Well Supply Company's Gulf Coast Division since May, 1945, has been appointed assistant treasurer of this U. S. Steel subsidiary, and will be in the company's headquarters at Dallas, Texas. This announcement was made by G. F. Goetzinger, "Oilwell" treasurer.

Shepherd has been connected with Oil Well Supply Company for 32 years. During 1944, he served with the Petroleum Administration for War.

● **Karl F. Gano** has been named manager of the Newark store and **William A. Grosenburg** manager of the Zanesville store of Oil Well Supply Company. They succeed **Ralph G. Oldaker** and **B. E. Grey,** respectively, who have been transferred to field sales duties.

● **John H. Kunkel,** until recently eastern manager of *Petroleo* and *California Oil World,* has joined International Advertisers, New York, export advertising agency, as account executive. Kunkel was formerly refinery editor of *The Petroleum Engineer* and for five years was associated with The Fluor Corporation, Ltd., Los Angeles.

● **Dr. Frank S. Hudson** has been made consulting geologist to Capital Company, Los Angeles, California, it has been announced by **Paul E. Terry,** vice president and general manager of the oil and gas division. He has been engaged in petroleum geology and engineering since 1920 for Union Oil Company of Delaware, Ventura Consolidated Oil Fields, and Shell Oil Company.

● **Fred Powell** has been appointed general manager of the El Segundo refinery of Standard Oil Company of California. He succeeds **W. W. Davison,** recently named a vice president of Standard. Powell was graduated from the University of Washington in 1922 as a chemical engineer and joined Standard in 1925, working at the Richmond refinery. He was made president of the California Refining Company, Standard affiliate at Barber, New Jersey, in 1946, which position he held until his new appointment.

Fred Powell

● **Ole Berg, Jr.,** has been elected to the board of directors of The British American Oil Company, Ltd., Toronto, Canada. He recently was appointed vice president and assistant to the president of the company.

● **W. E. Lasseter,** former Continental Supply Company sales representative at Duncan, Oklahoma, has been appointed store manager, succeeding **W. O. Begley, Jr.,** who will remain at Duncan, Oklahoma, in the capacity of field salesman.

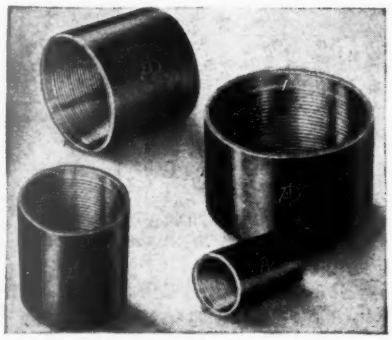
Other recent personnel changes announced by Continental are the appointment of **Glen R. Pike** as store manager of the Hobbs, New Mexico, store, succeeding **Noble D. Lane,** who has been transferred to the Fort Worth district office as district salesman. Pike was formerly field salesman at Hobbs.

**R. L. Faris,** former salesman at Corpus Christi, has been transferred to Continental's Export Division in New York City. He will serve in the same capacity at that point.

● **Edward Sampson,** Oceanside, California, is now acting as consultant for the William G. Madlener petroleum interests in Buenos Aires. Sampson was formerly associated with Pure Oil Company in a technical capacity and following that was plant superintendent for ten years with Velsicol Corporation at Marshall, Illinois.

● **P. R. Applegate** has been elected chairman of the board of directors of the Buckeye Pipe Line Company. **J. H. Peper** has been elected president. **G. S. Patterson** has been elected executive vice president. **H. K. Floyd** has been elected vice president and general manager. **A. J. Helmbrecht** has been appointed chief engineer.

● **W. H. Kolins** has been made superintendent of production of Frontier Chemical Company, Midland, Texas. He is a graduate of Ohio State University and has served the heavy chemical industry as production supervisor for Westvaco Chlorine Products, Michigan Chemical Company, and until May 1, Pine Bluff Chemical Company. He will supervise the manufacture of caustic soda and muriatic acid at Frontier's electrochemical plant at Denver City, Texas.

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Seamless
Steel

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MADE TO A. P. I. SPECIFICATIONS

Harrisburg's twenty-six years' experience and carefully controlled inspection result in a coupling of a superior type. The accuracy of the threads insures a perfect joint. Millions of Harrisburg Couplings are in use in all branches of the petroleum industry. We make our own steel.

**HARRISBURG MAKES:** Alloy and Carbon Steels; Seamless Steel $CO_2$ Liquefiers, Pipe Couplings, High Pressure Gas Cylinders; Drop and Hollow Forgings; Forged Steel Pipe Flanges; LP Gas Cylinders.

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HARRISBURG STEEL CORPORATION
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● **K. G. Walsworth** has been promoted from the status of petroleum engineer in charge of the Mt. Pleasant field office of the Michigan Department of Conservation to assistant petroleum geologist at the Lansing office. **V. F. Sargent** has been advanced to engineer in charge of the Mt. Pleasant field office. **Gordon Hautau** has been advanced to petroleum engineer in charge of all well testing and other studies related to production engineering and proration matters throughout the state. He will make his headquarters at Mt. Pleasant. **William Smiley** has been promoted to petroleum engineer assisting in the work supervised by Gordon Hautau.

● **C. A. Cash** has been promoted to the position of assistant to vice president in charge of operations of the Shamrock Oil and Gas Corporation, it is announced by J. H. Dunn, president. Cash was formerly chief engineer at Shamrock's McKee plants near Dumas, Texas, and will move to the headquarters of the company in Amarillo to work with **Harry Wheeldon,** vice president in charge of operations.

C. A. Cash

● **David B. Folkerth** of the General Electric Company's plastics sales office has been named Chemical Department district representative at the Pittsburgh office. Donald S. McKenzie, Chemical Department general sales manager, has announced.

● **Wilfed Sykes,** president of Inland Steel Company, has been elected to receive the 1948 Award of Merit by the Chicago Technical Societies Council, it has been announced by Dr. Gustav Egloff, president. Presentation ceremonies will take place at a special banquet meeting to be held by the Council in October.

● **F. W. Bremmer** has been named works manager of the Ambridge plant of The National Supply Company. He succeeds **W. M. Frame,** resigned. **Harold R. Beachler** was appointed works manager of the company's Etna plant, replacing Bremmer there. Beachler has been superintendent of the lapweld mills at Etna.

● **C. Porter Packard,** Canton, Massachusetts, has been made district manager of the Boston office territory of the Crocker-Wheeler Electric Manufacturing Company, division of Joshua Hendy Corporation.

● **H. D. Moore** has resigned as general sales manager of the W. T. Waggoner Estate properties, Vernon, Texas, to affiliate himself with the Wood River Oil and Refining Companies as executive assistant. Moore will be assistant to **Dr. H. B. Alspaugh,** executive vice president of Wood River companies, and will make his headquarters at the Duncan, Oklahoma, offices of the Rock Island Oil and Refining Company, Inc., a subsidiary of Wood River Company.

**Christmas-Tree Day Comes More Often**

**. . . faster round trips — made possible by LE ROI lugging power, acceleration, and dependability — mean quicker completions**

Time is the principal factor governing drilling costs. Le Roi engines reduce the time element and your costs in these three important ways:

● **They smooth out the load peaks** — horsepower over and above the engine rating — reserve horsepower — provides lugging power that gets you over the troublesome humps.

● **They give you more time on the bottom** — rapid acceleration, made possible by Le Roi's unique valve-in-head design, short stroke, and new carburetion, assures you of faster round trips.

● **They stay on the job** — sturdy design, easy accessibility, 100% interchangeability of parts, parts stocks in every producing area, all reduce downtime so that you make hole faster.

Le Roi engine sizes range from 4 to 600 horsepower. Le Roi's burn oil-field fuels — natural gas, butane, or gasoline. Let your Le Roi distributor show you the engineering features that save drilling time and money.

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LE ROI MILWAUKEE

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Le Roi Company Branch — Tulsa
Carson Machine & Supply Co. — Oklahoma City

**East & South Texas, Gulf Coast**
Southern Engine and Pump Company — Houston, Kilgore, Alice, Edinburg, Dallas, San Antonio, Texas, and Lafayette, Louisiana.

**North & West Texas, New Mexico**
Carson Machine and Supply Co.—Great Bend Falls, Odessa, Lubbock, Texas.

**Kansas**
Carson Machine and Supply Co.—Great Bend

**Illinois — Western Kentucky**
Western Machinery Company — Centralia, Illinois and St. Louis, Missouri.

**Michigan**
Hafer Engine Co. — Reed City

**Rocky Mountain Area**
Industrial Power Units, Inc. — Casper, Wyoming.

**Northern Louisiana & Mississippi**
Ingersoll Corporation — Shreveport, Louisiana, and Jackson, Mississippi.

**West Coast**
Le Roi-Rix Machinery Co. — Los Angeles, Calif.

**Appalachian Area**
Lloyd, Smith Company — Bradford, Penn.
P. C. McKenzie Co. — Pittsburgh

**Canada**
Drilling Supplies, Ltd. — Calgary, Alberta

*Complete Sales and Service Facilities*

*Makes No Difference WHERE The Differential OCCURS*

**Above The Element**

**Below The Element**

*You get a Positive Seal*

**with the**

# *Wilson*

*"Positive SEAL"*

# HOOK WALL PACKER

That's why more and more Wilson "Positive Seal" Packers are being set. When you eliminate leaks caused by the Hydrostatic Head being greater than the bottom hole pressure, you eliminate the cause of many packer failures.

In the design of the Wilson Packer, if the Differential is above, the rubber element is pressed against the seat, assuring a tighter seal-off. If the Differential is *below*, the patented split pack-off of the rubber element gives a "Lip-Seal"—the greater the pressure, the tighter the seal.

In any specified standard pipe size, one Packing element fits all weights of pipe. Contact your nearest Wilson Supply Store or write for complete information on this outstanding Wilson product.

## WILSON SUPPLY COMPANY

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# the Petroleum Engineer's CONTINUOUS TABLES

*a daily reference for operating men*

## INSTALLMENT No. 132

A valuable and regular feature of *The Petroleum Engineer*, the Continuous Tables, now in their eleventh year of publication, were designed to save time and effort for the technician and the practical field or plant worker. The tables have proved one of the most popular and helpful departments of *The Petroleum Engineer*. Data are presented in the simplest form available with many types of information included that are best presented by curves or nomographs when three or more variables must be considered simultaneously.

The Continuous Tables have been developed as a result of suggestions for new tables, direct contributions and improvements to existing tables by members of the petroleum and related industries, including manufacturing concerns, who are continually searching for practical information reduced by computation to tabular form readily applicable to the problems daily confronting them that might otherwise necessitate a more or less tedious calculation. These contributions and suggestions from the industry have resulted in a valuable exchange of information and data contributing to the progress of the industry as a whole.

This index will be revised monthly. The index for installments 1-12, inclusive, will be found in the May, 1938, issue; 13-24, inclusive, in the June, 1939, issue; 25-36, inclusive, in the June, 1940, issue; 37-48, inclusive, in the June, 1941, issue; 48-60, inclusive, in the June, 1942, issue; 61-72, inclusive, in the June, 1943, issue; 73-79, inclusive, in the January, 1944, issue; 80-82, inclusive, in the April, 1944 issue; 83-85, inclusive, in the July, 1944, issue; 86-88, inclusive, in the October, 1944, issue; 89-91, inclusive, in the January, 1945, issue; 92-94, inclusive, in the April, 1945, issue; 95-97, inclusive, in the July, 1945, issue; 98-100, inclusive, in the October, 1945, issue; 101-103, inclusive, in the January, 1946, issue; 104-106, inclusive, in the April, 1946, issue; 107-109, inclusive, in the July, 1946, issue; 110-112, inclusive, in the October, 1946, issue; 113-115, inclusive, in the January, 1947, issue; 116-118, inclusive, in the April, 1947, isisue; 119-121, inclusive, in the July, 1947, issue; 122-124, inclusive, in the October, 1947, issue; 125-127, inclusive, in the January, 1948, issue; 128-130, inclusive, in the April, 1948, issue.

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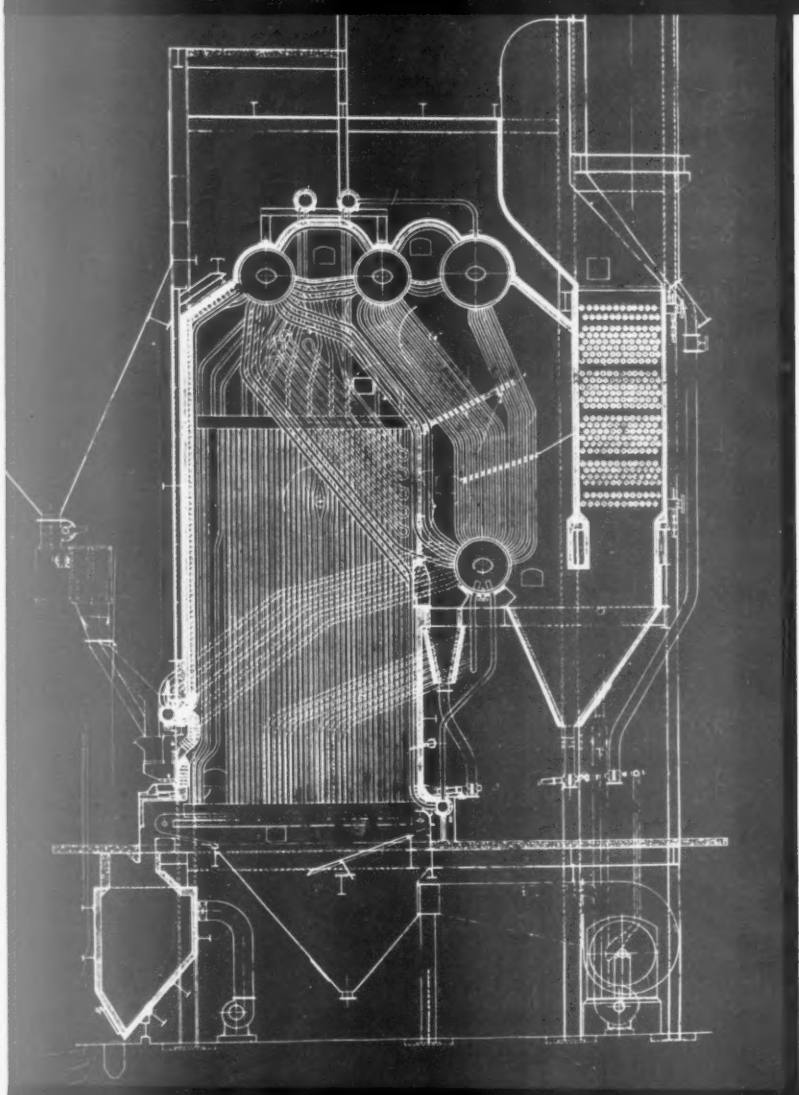
# Another WICKES BOILER for Morton Salt Company



When engineers of the Morton Salt Company specified a Wickes 4-Drum Boiler for the Morton plant at Manistee, Michigan, their choice was dictated in part by proven Wickes performance. For this is the *second Wickes boiler* installed at Morton's Manistee plant—evidence that *Wickes design and construction delivers the efficiency* that industry demands of a power generating unit. Cummins & Barnard, Inc., Engineers, of Ann Arbor, Michigan were consulting engineers on this installation. Specifications include: 180,000# steam per hour capacity, design pressure 700 psi, and total temperature 750° F. The advantages of Wickes 4-Drum Boiler design are readily apparent. Large diameter drums, minimum number of tube bends, and steam liberating area large enough to insure *rapid response to load changes.* For boilers of any type with capacities up to 250,000 lb. steam per hour and 850 psi, *consult Wickes first.* We are completely equipped to design and build boilers to specific requirements.

# THE WICKES BOILER CO.

**DIVISION OF THE WICKES CORPORATION • SAGINAW, MICHIGAN**

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**RECOGNIZED QUALITY SINCE 1854**

# PROPERTIES OF HIGH YIELD STRENGTH SEAMLESS LINE PIPE

Steel has been almost universally used for pipe line construction and one of the most important developments in the application of this material has been the field welding of joints. It is the generally accepted practice to weld line pipe without preheat, a postheat, or the use of a back-up strip. Such practice, however, requires a proper steel and welding technique. After the pipe has been welded, it is frequently coated with a bitumastic or other material to prevent soil corrosion. Anodic protection of the pipe may also be used to inhibit corrosion. A special corrosion resistant steel, therefore, is not required in pipe line construction as other methods have been developed for protecting the outside and inside surfaces of the pipe.

● **Materials.** The chemical and physical properties of the various steels used in this investigation and the type of material tested are shown in Table 1. Chemical and physical properties of the weld metal in the as-welded condition are shown in Table 2. Electrodes $V_1$, $V_2$, and $V_3$, although of the same type, were of different manufacture. All open hearth steels were tested in the as-rolled condition and the induction furnace heats were normalized.

The chemical and physical properties of approximately 350-160-ton heats of steel, which have been rolled into 26-in. OD by 0.303-in. wall line pipe, are as follows:

| | Specification | Actual range |
|---|---|---|
| Carbon | 0.40% max. | 0.30-0.39% |
| Manganese | 1.40% max. | 0 94-1.36% |
| Phosphorus | 0.040% max. | 0.007-0.027% |
| Sulphur | 0.050% max. | 0.017-0.047% |
| Alloys | | Residual |
| Yield strength (psi) | 52,000 min. | 53,500-74,000 |
| Ultimate strength (psi) | 75,000 min. | 79,400-100,000 |
| Elongation in 2 in. | 22% | 22.5-38.0% |

The 26-in. OD by 0.303-in. wall line pipe used in this investigation was selected from the above heats. The other types of material tested were melted on the basis of chemistry, as all of the regular production heats had not been melted at the time of the experimental program.

● **Testing methods.** *Girth welds.* Circumferential welding of full pipe sections was used in this investigation. The pipe was rotated and manual metallic arc welded with coated electrodes in a down hand position. After tack welding, a root or stringer bead was applied, followed by a filler bead and finally a face or cover bead. The type of joint and welding sequence is shown in Fig. 1. Possible modifications of the welding sequence described in Fig. 1 are indicated elsewhere in this investigation. Except where noted, the girth welds were not preheated, postheated, or stress relieved.

*Weld bead tests.* In order to reduce the variables associated with manual metallic arc welding, weld bead tests shown in Fig. 1 were made at the U. S. Steel Corporation Research Laboratory.

**TABLE 1. Chemical and physical properties of the steel tested.**

| Code no. | Type | Process | C | Mn | P | S | Si | Yield 1000 psi | Ultimate 1000 psi | Per cent elongation in 2 in. |
|---|---|---|---|---|---|---|---|---|---|---|
| A | 26" OD x 0.303" wall pipe | O.H. | 0.36-0.39 | 1.24-1.28 | 0.014 | 0.033 | .. | 55-69 | 86-100 | 27-35 |
| B | 18" OD x 0.312" wall pipe | O.H. | 0.38 | 1.42 | 0.010 | 0.023 | 0.24 | 65 | 98 | 28 |
| C | 20" OD x 0.312" wall pipe | O.H. | 0.22 | 0.47 | 0.008 | 0.022 | .. | 43 | 64 | 42 |
| D | 26" OD x 0.303" wall pipe | O.H. | 0.30 | 1.12 | 0.011 | 0.023 | .. | | | |
| E | 26" OD x 0.303" wall pipe | O.H. | 0.31 | 1.26 | 0.011 | 0.022 | .. | | | |
| F | 26" OD x 0.303" wall pipe | O.H. | 0.36 | 1.14 | 0.009 | 0.021 | .. | | | |
| G | 26" OD x 0.303" wall pipe | O.H. | 0.37 | 1.36 | 0.010 | 0.026 | .. | | | |
| H | 0.303" gage plate | I.F. | 0.32 | 1.35 | 0.016 | 0.027 | 0.08 | | | |
| I | 0.303" gage plate | I.F. | 0.37 | 1.37 | 0.016 | 0.027 | 0.08 | | | |
| J | 0.303" gage plate | I.F. | 0.41 | 1.16 | 0.015 | 0.026 | 0.05 | | | |
| K | 0.303" gage plate | I.F. | 0.40 | 1.34 | 0.016 | 0.025 | 0.07 | | | |
| L | 0.303" gage plate | I.F. | 0.40 | 1.42 | 0.011 | 0.019 | 0.09 | | | |

O.H.—Basic Open Hearth. I.F.—Induction Furnace.

**TABLE 2. Chemical and physical properties of the weld metal.**

| Electrode | Typical analysis of deposited metal | | | | | | | | Yield 1000 psi | Ultimate psi | Per cent elongation in 2 in. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | C | Mn | Si | P | S | Mo | V | Cr | | | |
| (U) E-6010 | 0.10-0.14 | 0.40-0.55 | 0.01* | 0.030* | 0.035* | .. | .. | .. | 53-60 | 65-77 | 22-30 |
| ($V_1$) E-7010 | 0.09-0.13 | 0.50-0.65 | 0.10 | 0.035* | 0.035* | 0.50-0.55 | .. | .. | 62-66 | 77-82 | 18-25 |
| ($V_2$) E-7010 | 0.08 | 0.70 | 0.28 | 0.019 | 0.015 | 0.48 | .. | .. | 62-70 | 73-85 | 20-25 |
| ($V_3$) E-7010 | 0.07 | 0.34 | 0.15 | 0.017 | 0.022 | 0.52 | .. | .. | 57-63 | 72-80 | 25-28 |
| (W) E-8011 | 0.11 | 0.34 | 0.19 | 0.012 | .. | 0.52 | .. | 0.54 | 73-75 | 88-90 | 19-20 |
| (X) E-10010 | 0.09-0.13 | 0.50-0.65 | 0.10 | .. | .. | 0.70-0.85 | 0.10-0.15 | .. | 90-100 | 103-112 | 14-17 |

*Maximum.

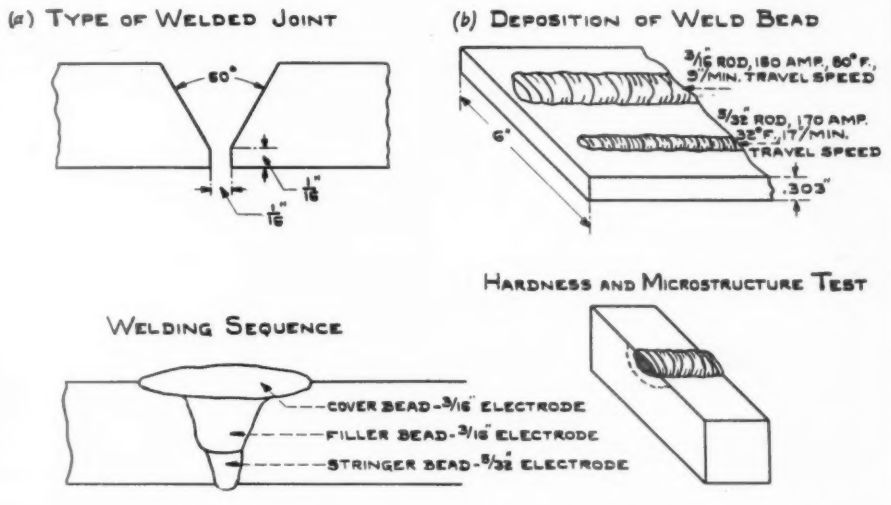


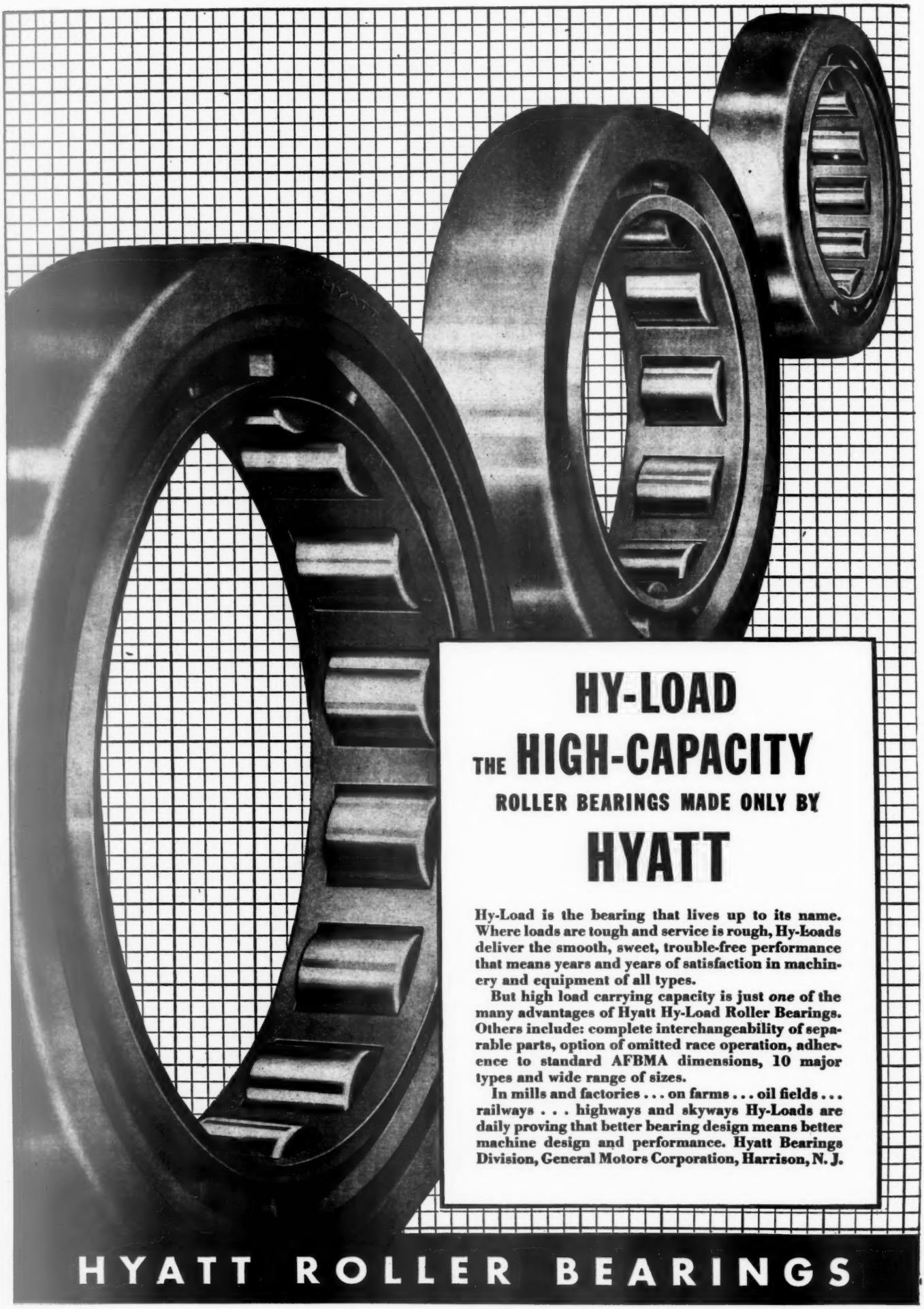

**FIG. 1. Type of welded joints and weld bead tests used in investigation.**

These beads were deposited with an automatic welding head with a stick electrode attachment. As may be noted from Fig. 1, two single weld beads were deposited on each steel specimen. One bead, 6 in. in length, was deposited using a 3/16-in. diam electrode with 180 amp and 9 in. per min travel speed. The plate was at 80 F prior to deposition of this bead. A second bead, 3 in. in length, was deposited using a 5/32-in. diam electrode with 170 amp and 17 in. per min travel speed. The plate was cooled to 32 F prior to deposition of this bead. The reason for depositing two beads of such widely different characteristics was to represent (1) normal or average welding practice and (2) the most unfavorable welding conditions that might be encountered, particularly in tack welding. An E-7010 welding rod was used for both beads. A transverse section of the weld bead test was examined and the micro-structure and hardness evaluated. A longitudinal section of pipe was also used so that the beads would be deposited under conditions similar to the plate specimens.

---

Taken from the article, "Metallurgical properties of high yield strength seamless line pipe," by A. B. Wilder[1] and J. D. Tyson[2] that was presented before the American Welding Society, Chicago, Illinois, October 18-24 and published in *Welding Journal*, and published in *The Petroleum Engineer*, February, 1948, pages 138 to 152, inclusive.

1. Chief Metallurgist, National Tube Company.
2. Chief Metallurgist, Lorain (Ohio) Works, National Tube Company, subsidiary of United States Steel Corporation.



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# DESIGN AND CONSTRUCTION OF GAS COMPRESSOR PLANTS

The design of every repressuring plant should be sufficiently flexible to permit expansion or reduction in capacity or in operating pressure as changing conditions, brought about by an increase in the repressured area or by the depletion of the reservoir, may require. Therefore, generally it will be found to be more practical to install several compression units of moderate size rather than one large unit capable of supplying the entire calculated output. Whether all the compressors should be housed in one building or should be distributed about as individual units will depend, among other things, upon the geography of the field, the amount of new pipe line construction that will be required, and upon the possible future expansion of the project. In some of the intermittent type of injection systems, which have gained considerable popularity in certain of the eastern fields, the use of small, semi-automatic units, that require only periodic attention, has proved to be very practical. Elsewhere, and especially in unitized fields, integrated operations may result in economies that cannot be overlooked. No fixed rule that might be applied to all conditions may be offered, and the foregoing discussion is presented principally to focus attention to the need for competent engineering supervision in the formulation of plans for each particular project.

● **III. The design of compressor plants.** *(1) The compression of gas.* The gas repressuring of older fields as a means for increasing oil recovery involves the compression of the injection medium and its subsequent introduction into the reservoir by means of intake wells. Practically all compressors employed for this work are of the reciprocating type that may be operated by direct connection to the source of power by a connecting rod or by a belt drive. The compressor will consist of one or more cylinders containing close-fitting pistons and valves so arranged and operated to permit the intake of low pressure gas and the escape of high pressure gas into and from the compression cylinder. Most modern compressors are double acting; that is, gas is taken into the cylinder at the crank end while it is being discharged from the head end on the up stroke of the piston and vice versa on the return stroke. However, on some of the smaller projects, single acting compressors are still in use.

In actual practice the compression of gas always involves some change in temperature and there is always some loss of heat due to radiation from the cylinders and to water or oil cooling. Thus, the process of compression is not truly isothermal; neither is it truly adiabatic, but rather it is in an intermediate stage known as polytropic and may be expressed in accordance with the following formula:

$$P_1V_1^n = P_2V_2^n = C \quad . \quad . \quad . \quad . \quad (1)$$

Where:

P = absolute pressure of the gas in lb. per sq. in.,
V = volume of the gas in any convenient units,
n = the exponent of compression, and
C = a constant.

The exponent of compression "n" may be determined from an indicator diagram and according to Gill[6] is dependent upon the characteristics of the gas compressed, the degree of cooling, the condition and design of the compressor valves, and to the condition of the rings in the compression cylinder. Operating experience has indicated that an approximate value of 1.2 for "n" is fairly close to actual conditions in the average compressor, but may vary depending on whether dry or wet natural gas or air-gas mixtures of varying proportions are used.

*(2) Power requirements of compressors and fuel control.* With the value of "n" either determined or assumed, the horsepower required for the compression of a given quantity of gas in a given length of time can be determined. For all practical purposes, the power required for compression is of less importance and should not be confused with the somewhat larger brake horsepower that the prime mover must deliver to the compressor both to compress the gas and to overcome the friction in the moving parts of the compressor. According to Gill[6], the brake horsepower can be calculated by the use of the following formula:

$$\text{B.hp. per MM. cu. ft.} = \left[\frac{44.5\,n}{n-1}\left(R^{\frac{n-1}{n}} - 1\right) + 10\right]\left[1 + \frac{R^2}{350}\right] \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

Where:

B.hp. per MM. cu. ft. = b.hp. of compression per million standard cu. ft. of gas at 14.7 lb. per sq. in. and 60°F. per 24 hr.,
n = exponent of compression
R = pressure ratio $\frac{P_2}{P_1}$
$P_2$ = discharge pressure in lb. per sq. in., abs., and
$P_1$ = intake pressure in lb. per sq. in., abs.

In equation (2) the constant "10" is regarded as being applicable for compressors up to a range of 200 to 300 hp, generally about the maximum size used in secondary recovery work.

The supply of fuel gas for compressor engines must be regulated precisely and the apparatus for this purpose should be of simple construction and should not require frequent repairs or adjustments. The last regulator should be sufficiently sensitive to maintain the pressure with a variation of less than 1 per cent. For installations where more than one four-cycle compressor unit are required, a common fuel header, of sufficient size that there will be a pressure drop of only from 3 to 5 in. of water for the entire length, has proved to be quite satisfactory. Where the use of air-gas mixtures for fuel can be anticipated, adequate provision should be made for increased intake of fuel in relation to air.

Ignition of the gas in the compressor engine has usually been by means of magnetos or by direct-current impulses from storage batteries. Quite recently individual direct-current rectifiers of the copper oxide type have been developed as a substitute for the forms of ignition equipment just cited. These units utilize electric energy from a 440-volt, 3-phase, 60-cycle source, and with an integral transformer, they supply steady and uniform direct current for the ignition system of all engines.

*(3) Displacement and capacity of compressors.* The volumetric displacement of a compressor is the volume of gas, measured at intake conditions of temperature and pressure, that the compressor will handle for any given time period. For a single acting compressor it may be determined by the following equation:

$$D_n = 0.000454d^2LN \quad . \quad . \quad . \quad . \quad . \quad (3)$$

Where:

$D_n$ = nominal displacement in cu. ft. per min.;
d = bore of compressor cylinder, in.;
L = length of piston stroke, in., and
N = speed of compressor, rpm.

If the nominal displacement in M. cu. ft. per 24 hr. is desired, equation (3) can be changed as follows:

$$D_n = \frac{0.000454\ d^2\ LN \times 60 \times 24}{1000}. \quad (4)$$

For double-acting compressors, a correction in either equation (3) or equation (4) must be made for the reduced capacity on the reversed stroke because of the volume of the piston rod extending through the cylinder. Ordinarily, these corrections may be obtained from tabulations supplied by compressor manufacturers, but should these not be available the factors may be determined by actual measurement of the bore of the cylinder, the length of piston stroke, the dimensions of the piston, and the diameter and length of the piston rod.

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NOTE: References are shown on the last sheet in this series.

Taken from the article "Design and construction of compressor plants," by Paul D. Torrey that was presented before American Petroleum Institute Southwestern District Division of Production, Shreveport, Louisiana, May 17 and 18, 1946, revised in 1947, and published in *The Petroleum Engineer*, December, 1947, pages 108 to 126, inclusive.

# GRAY

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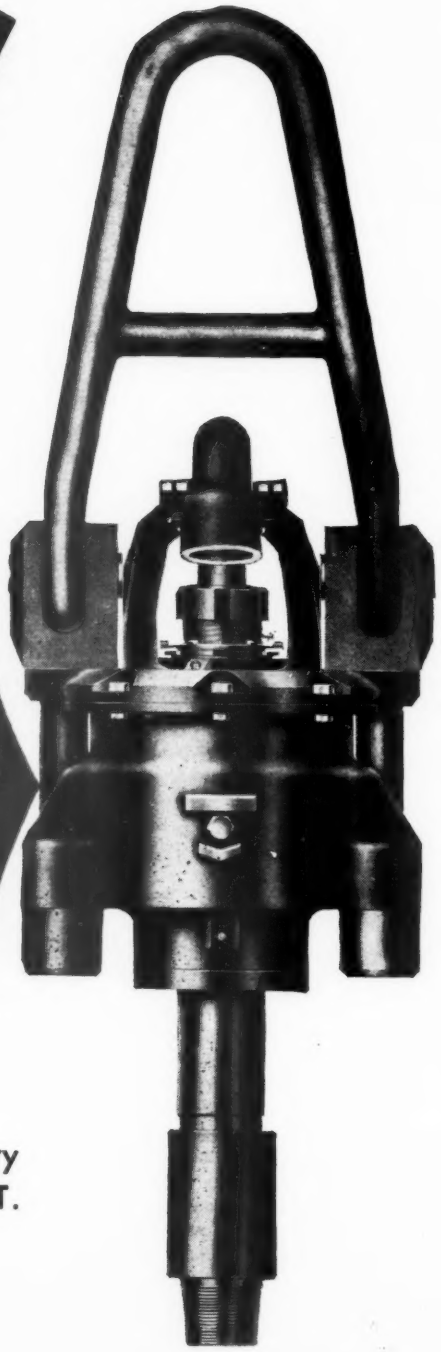

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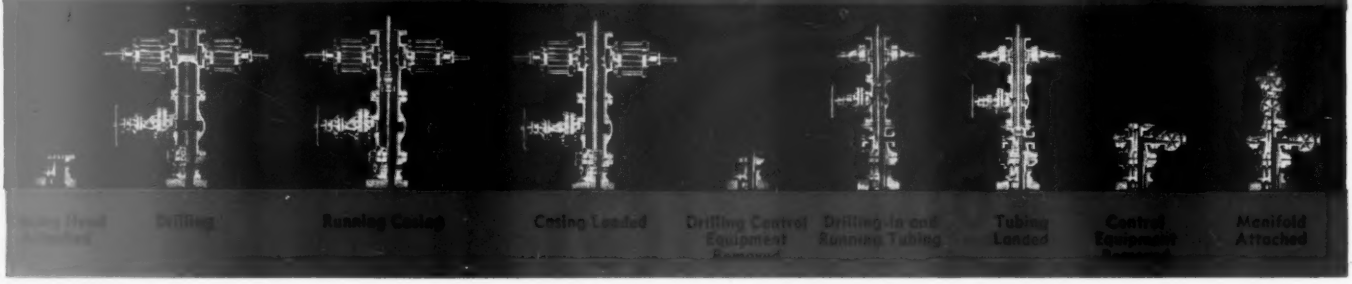

# PROPERTIES OF INTERMEDIATE ALLOY STEELS AT ELEVATED TEMPERATURES

THE development of the petroleum, chemical, and power industries to a greater efficiency and economy depends to a considerable extent upon the use of higher and higher operating pressures and temperatures; higher stresses at higher temperature for the steel involved. Representative installations requiring steels for service at high temperatures and pressures include oil stills, cracking units, pumps, valves, pressure tanks, boilers, superheaters, and high pressure steam piping.

In view of the requirements and possible safety hazards involved in this type of service, the steels used should have the following qualities:

(a). Adequate strength at elevated temperatures.

(b). Resistance to oxidation and attack by the corroding media to which it may be exposed in service.

(c). Good ductility and toughness during its period of service.

(d). Weldability, if the application involves welding.

(e). Generally satisfactory fabrication characteristics, i.e., suitable for rolling, forging, or tube piercing.

Tables 1 to 10 list the steels most commonly used in the petroleum refining industry, together with their properties at elevated temperatures. The ASME maximum allowable stress is taken from Table U-2 of the ASME Code for Unfired Pressure Vessels and represents a summary of the best available information, plus a factor of safety, based on service experience. A special ruling of the ASME Boiler Code Committee permits the increase of the maximum allowable working stresses by a factor of 1.25 under certain conditions.

Tensile, creep, and rupture properties listed in the tables and used in drawing the curves are based on tests carried out in the research laboratories of the United States Steel Corporation combined with the best available data from the literature (see bibliography). The spread in values is due primarily to three factors, namely:

1. *Heat treatment.* The strength of steels at elevated temperatures is profoundly affected by the heat treatment employed for the material. Carbon and molybdenum steels are used in the as-rolled, normalized, or annealed condition, while the air-hardening chromium-molybdenum steels are normalized and tempered or annealed. The annealing practices employed vary, and include the sub-critical or stress-relief anneal (a high temperature tempering treatment), the mill or process anneal at temperatures within the critical range, and the full anneal from above the critical range.

NOTE: References are shown on the last sheet in this series of tables.

Taken from the exclusive article, "Intermediate alloy steels at elevated temperatures," by R. F. Miller, Research and Technology Division of Carnegie-Illinois Steel Corporation, published in *The Petroleum Engineer*, January, 1948, pages 178 to 189, inclusive.

**TABLE 1. 0.5 per cent molybdenum steel—properties at elevated temperature*. Composition range covered by specifications (per cent).**

C 0.08/0.28 | Mn 0.30/0.90 | Si 0.10/0.50 | P 0.040 max | S 0.050 max | Mo 0.40/0.65

| Property | Temperature, F | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 700 | 800 | 900 | 1000 | 1100 | 1200 | 1300 | 1400 |
| ASME Maximum allowable stress† (1000 psi) | 10.6-15.0 | 10.4-14.4 | 10.0-10.4 | 5 0 | | | | |
| Tensile strength (1000 psi) | *61.0-74.0* 68.0 | *56.0-71.0* 63.5 | *50.5-66.0* 57.0 | *43.5-57.5* 48.0 | *35.0-42.0* 37.5 | *24.5-29.0* 26.5 | *16.0-20.0* 18.0 | *10.0-13.0* 11.5 |
| Yield strength (1000 psi) | *27-28* 24 | *20-28* 24 | *20-28* 24 | *20-27* 23 | *16-24* 20 | *13-18* 15 | *9.5-13* 11 | *5.5-6* 5.5 |
| Elongation (per cent in 2 in.) | *30-38* 35 | *28-36* 33 | *25-35* 30 | *29-40* 33 | *32-48* 40 | *38-60* 50 | *50-80* 68 | *77-94* 88 |
| Reduction of area (per cent) | *60-80* 70 | *62-82* 72 | *64-84* 75 | *67-86* 78 | *70-88* 82 | *72 90* 85 | *80-95* 90 | *85-100* 95 |
| Creep strength 1 per cent in 10,000 hr (1000 psi) | | *26-33.5* 30 | *16-30* 20 | *9-22* 12 | *2-4* 3 | *1-2* 1.5 | | |
| Creep strength 1 per cent in 100,000 hr (1000 psi) | | *16-23.5* 18 | *8-24* 12 | *3 11* 5 | *1-2* 1.5 | *0.2-0.9* 0.4 | | |
| Rupture strength 1000 hr—(1000 psi) | | | *40-53* 44 | *24-37.5* 28 | *8-8.5* 8.2 | | | |
| Rupture strength 10,000 hr—(1000 psi) | | | *32-52* 34 | *12.5-22* 16 | 5 | | | |
| Oxidation (weight loss in grams per sq in. after 168 hr in air at the indicated temperatures) | nil | nil | nil | 0.03 | 0.06 | 0.35 | 0.71 | 1 49 |
| Linear thermal expansion (inches per foot—from 70 F to the indicated temperatures) | | 0.067 | | 0.089 | | 0 111 | | |

*Values in italics show spread of available data, and accompanying single values are a conservative average of the data. Single values, only, represent limited data.

†For this grade, the allowable stresses differ, depending on the particular specification being used.

**TABLE 2. 1 per cent molybdenum steel—properties at elevated temperatures*. Composition range covered by specifications (per cent).**

C 0.10/0.20 | Mn 0.30/0.60 | Si 0.10/0.20 | P 0.040 max | S 0.045 max | Mo 0.90/1 10

| Property | Temperature, F | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 700 | 800 | 900 | 1000 | 1100 | 1200 | 1300 | 1400 |
| ASME Maximum allowable stress (1000 psi) | | | | | | | | |
| Tensile strength (1000 psi) | 67 | 66 | 64 | 58 | 52 | 39 | | |
| Yield strength (1000 psi) | | | | | | | | |
| Elongation (per cent in 2 in.) | | | | | | | | |
| Reduction of area (per cent) | | | | | | | | |
| Creep strength 1 per cent in 10,000 hr (1000 psi) | | 35 | *27-27.5* 27 | *11.6-13.8* 13 | | | | |
| Creep strength 1 per cent in 100,000 hr (1000 psi) | | 25 | 11 | 5.5 | | | | |
| Rupture strength 1000 hr—(1000 psi) | | | | | | | | |
| Rupture strength 10,000 hr—(1000 psi) | | | | | | | | |
| Oxidation (weight loss in grams per sq in. after 168 hr in air at the indicated temperature) | nil | nil | nil | 0.04 | 0.07 | 0.55 | 1.14 | 1.71 |
| Linear thermal expansion (inches per foot—from 70 F to the indicated temperatures) | | 0.069 | | 0.092 | | 0.115 | | |

*Values in italics show spread of available data, and accompanying single values are a conservative average of th data. Single values, only, represent limited data.

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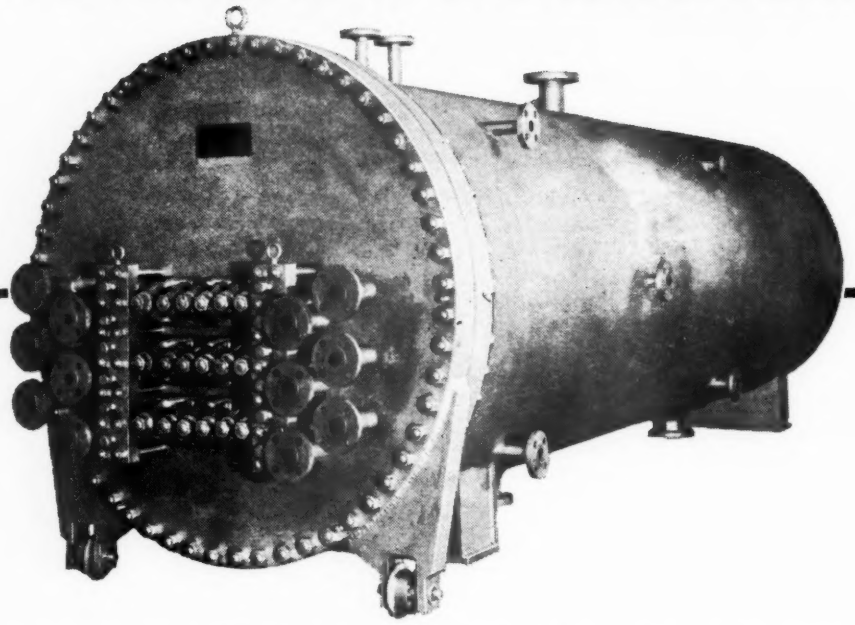

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# DESIGN AND CONSTRUCTION OF GAS COMPRESSOR PLANTS

*(4) Efficiency of compressors.* The volumetric efficiency of a compressor is the ratio of the volume of gas actually handled under the conditions of pressure and temperature prevailing at the intake to the volume discharged by the compressor piston in a given time period. It is a function of the clearance ratio, which is the ratio of the clearance volume to the displacement volume, the ratio of absolute discharge pressure to absolute intake pressure, and the exponent of compression, as defined in Title III-1 herein. As stated by Gill[6]:

$$E_v = 0.98 - c(R^{1/n} - 1) \quad . \quad . \quad . \quad . \quad (5)$$

Where:

$E_v$ = volumetric efficiency,
$c$ = clearance ratio (clearance is the volume of space in the compressor cylinder enclosed between the cylinder wall, piston face and valves when the piston is at the end of the stroke for the given end of the cylinder),
$R$ = ratio of absolute discharge pressure to absolute intake pressure, and
$n$ = exponent of compression.

*(5) Effect of supercompressibility of natural gas on compressor performance.* When conditions of pressure and temperature prevail that cause the gas that is to be compressed to deviate from the ideal gas laws, consideration must be given to the supercompressibility factor in order to predict accurately the volume throughput and the horsepower requirements for the plant. The effect of supercompressibility is more prominent at high pressures, but even in low pressure operations, if gas carrying an appreciable hydrocarbon content heavier than methane is being handled, there may be a very considerable deviation. Consequently, unless the effect of the supercompressibility factor is understood, it may be discovered, after compressors have been installed, that the throughput volume and the horsepower requirements are much larger than that calculated.

The effect of supercompressibility of natural gas upon compressor performance has been treated very adequately by Ridgeway[7] who has developed the following formulae for the determination of cylinder capacity:

Cylinder capacity = cylinder capacity calculated neglecting supercompressibility $\times \dfrac{E_{vs}}{E_v \times Z_s}$ . . . . (6)

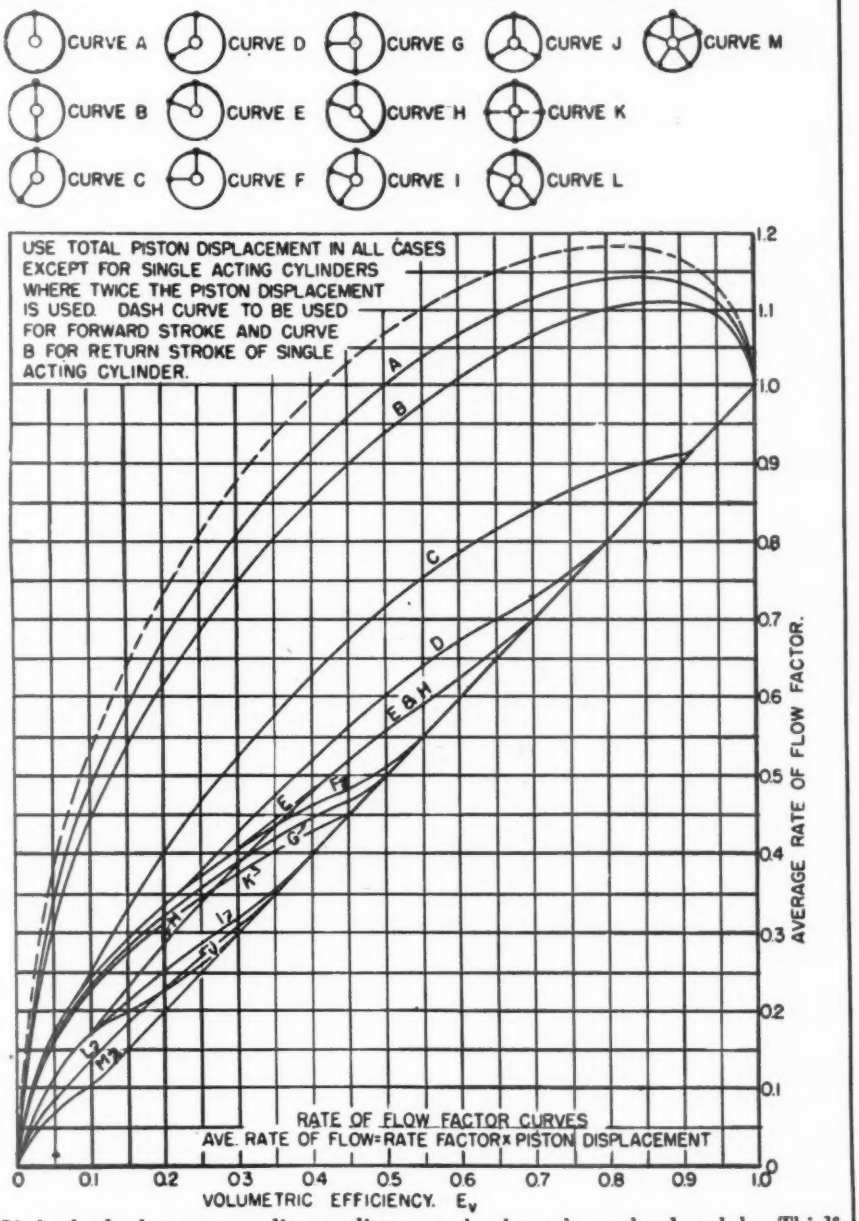
$$= \text{cylinder displacement} \times \frac{E_{vs} \times \text{suction lb. per sq. in. abs.} \times 520^\circ}{Z_s \times 14.7 \times (460 + t^\circ \text{ suction})} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

Where:

$E_{vs}$ = volumetric efficiency,
$E_v$ = volumetric efficiency, and
$Z_s$ = supercompressibility at suction pressure and temperature.

FIG. 1. Rate of flow factor curves.

*From "Calculating Pipe Sizes for Compresser Cylinder," by B. C. Thiel, The Petroleum Engineer, November 1943, p. 135.*




If the brake horsepower disregarding the supercompressibility factor has been determined for a unit volume of the gas to be handled, the brake horsepower requirements recognizing supercompressibility can be ascertained by multiplying the theoretical brake horsepower by the average of the suction and discharge supercompressibility factors. However, as discussed in detail by Ridgeway[7], since the effect of supercompressibility is to increase the capacity of the compressor cylinder, the horsepower requirement will increase proportionately as the actual expanded volume bears to the expanded volume calculated according to the ideal gas laws.

Methods for the determination of the average momentary flow rate for the cylinder during the suction or discharge stroke have been developed by Thiel[8] and may be used to calculate the most efficient size of intake and discharge pipe fittings. In discussing a rate factor curve, Fig. 1, which eliminates much of the burdensome graphical analysis of calculation, Thiel states: "This curve, (Fig. 1), is based on a double acting compressor cylinder having a crank rod ratio of 1 to 5. This ratio was chosen because it is closer to the present-day American practice.

NOTE: References are shown on the last sheet in this series.

Taken from the article "Design and construction of compressor plants," by Paul D. Torrey that was presented before American Petroleum Institute Southwestern District Division of Production, Shreveport, Louisiana, May 17 and 18, 1946, revised in 1947, and published in *The Petroleum Engineer*, December, 1947, pages 108 to 126, inclusive.

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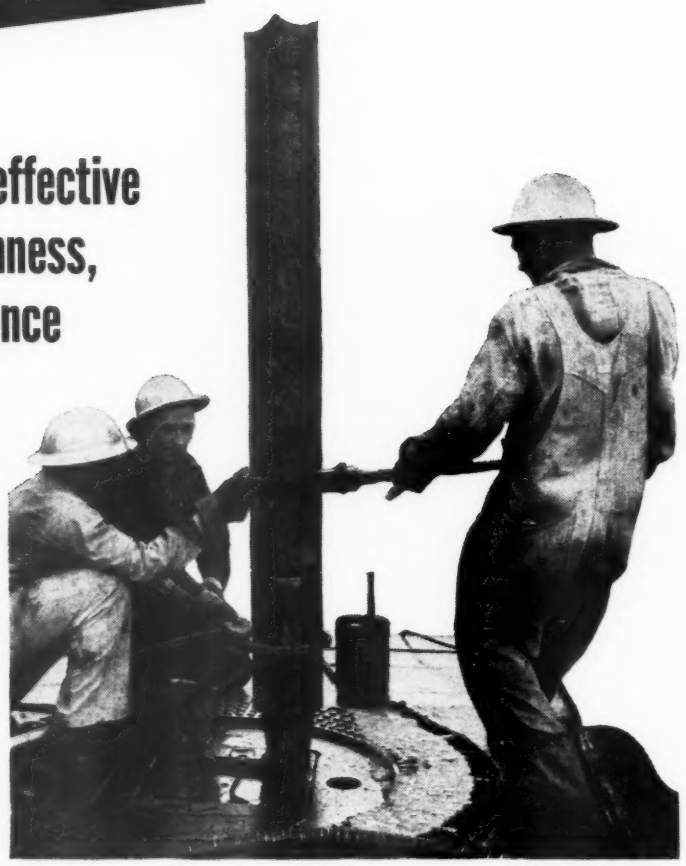

Making up "sub" on a drill collar. Greater safety is assured in deep well drilling through the use of alloy steels for drill collars and the "subs" or substitutes which connect them. Alloy steels help increase safety in drilling, too, when used for drill bits, tool joints, kellys, swivels, blocks, pumps, draw works and high-pressure equipment. Ask Republic metallurgists what these steels can do for you.

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# PROPERTIES OF INTERMEDIATE ALLOY STEELS AT ELEVATED TEMPERATURES

The relative importance of these characteristics depends upon the application, but creep strength and corrosion resistance are of prime importance. It has been found that the determinations of tensile strength, yield strength, and elastic limit, when measured in a short time test at high temperature, are inadequate. When materials are maintained at high temperature even under a relatively low stress, a gradual yield or extension occurs. This gradual yield, because of its small magnitude, has been termed "creep" and is customarily expressed in terms of stress for a given rate of elongation. For example, the stress that causes elongation at a rate of 1 per cent per 100,000 hr, or of 1 per cent elongation per 10,000 hr, is termed the creep stress for the material at the particular temperature involved. For certain applications, such as steam turbines, total elongation rather than the rate is of greatest importance, for the operational tolerances are very small; furthermore materials under stress at high temperature do not necessarily elongate most rapidly during the early period of service. The stress for rupture in a certain time period is also used as a basis for design, particularly where the amount of deformation may be large enough to result in failure of the metal during its service life.

Factors influencing the creep and rupture characteristics are primarily the presence of effective alloys and the microstructure that has been induced by suitable heat treatment. Study of this problem has been extensive and, although it is believed that the alloying elements that have low diffusion rates and form carbides, such as molybdenum, chromium, tungsten, vanadium, and titanium, are most effective in producing a steel of high creep strength, other elements are frequently used either to assist in obtaining this quality or for oxidation and corrosion resistance.

The steels are purchased to specifications having room temperature mechanical strength and hardness requirements, and the steels are heat treated to produce these properties. As these properties may be produced by several of the above heat treatments, few, if any, of the various types of steel are used in only one condition of heat treatment, accounting for much of the spread in the data. It should be emphasized that the specifications do not contain requirements concerning the properties of the steels at elevated temperatures.

NOTE: References are shown on the last sheet in this series of tables.

Taken from the exclusive article, "Intermediate alloy steels at elevated temperatures," by R. F. Miller, Research and Technology Division of Carnegie-Illinois Steel Corporation, published in *The Petroleum Engineer*, January, 1948, pages 178 to 189, inclusive.

**TABLE 3. 1.25 per cent Cr, 0.75 per cent Si, 0.50 per cent Mo—properties at elevated temperatures*. Composition range covered by specifications (per cent).**

| C | Mn | Si | P | S | Cr | Mo |
|---|---|---|---|---|---|---|
| 0.15 max | 0.30/0.60 | 0.50/1.0 | 0.040 max | 0.050 max | 1.0/1.5 | 0.45/0.65 |

| Property | Temperature, F | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 700 | 800 | 900 | 1000 | 1100 | 1200 | 1300 | 1400 |
| ASME Maximum allowable stress (1000 psi) | 12.0 | 11.8 | 10.0 | 5.85 | 2.2 | | | |
| Tensile strength (1000 psi) | *72.5-74.5* 73 | *69-72* 71 | *64-67.5* 65 | *54-57.5* 56 | *40-47.5* 44 | *27-33* 30 | *17-22.5* 20 | *11-13.5* 12 |
| Yield strength (1000 psi) | | *26-39.5* 32.5 | *25.5-35* 31.5 | *24.5-31.5* 27.5 | *23-25.5* 24 | *16-19* 17.5 | 11 | 7 |
| Elongation (per cent in 2 in.) | | *23-30* 25 | *24-29* 26 | *26-31* 29 | *29-41* 34 | *32-55* 45 | 61 | 72 |
| Reduction of area (per cent) | | 66 | 68 | 74 | 82.5 | 89 | 94 | 98 |
| Creep strength 1 per cent in 10,000 hr (1000 psi) | | *27-29* 28 | *17-25* 20.5 | *8-22.5* 12 | *3.5-7.5* 6 | *1.5-3.8* 2.5 | | |
| Creep strength 1 per cent in 100,000 hr (1000 psi) | | 20.5 | 14.5 | *8-13* 8.5 | *2-4.5* 3 | *0.8-2* 1 2 | | |
| Rupture strength 1000 hr—(1000 psi) | | | | | | 7 | 2.8 | 0.9 |
| Rupture strength 10,000 hr—(1000 psi) | | | | | 10.8 | 4 | 1 3 | 0.4 |
| Oxidation (weight loss in grams per sq in. after 168 hr in air at the indicated temperatures) | nil | nil | nil | 0.02 | 0.07 | 0.24 | 0.67 | 1.19 |
| Linear thermal expansion (inches per foot—from 70 F to the indicated temperatures) | | 0.066 | | 0.087 | | 0 110 | | |

*Values in italics show spread of available data, and accompanying single values are a conservative average of the data. Single values, only, represent limited data.

**TABLE 4. 1.75 per cent Cr, 0.75 per cent Si, 0.75 per cent Mo—properties at elevated temperatures*. Composition range covered by specifications (per cent).**

| C | Mn | Si | P | S | Cr | Mo |
|---|---|---|---|---|---|---|
| 0.15/0.25 | 0.40/0.60 | 0.45/0.75 | 0.040 max | 0.050 max | 1.5/2.0 | 0.60/0.80 |

| Property | Temperature, F | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 700 | 800 | 900 | 1000 | 1100 | 1200 | 1300 | 1400 |
| ASME Maximum allowable stress (1000 psi) | 12.0 | 11.8 | 10.0 | 5.85 | 2.2 | | | |
| Tensile strength (1000 psi) | 73 | 71.5 | 66.5 | 56 | 42 | 29 | 19 | 11 |
| Yield strength (1000 psi) | 47.5 | 46 | 43 | 40 | | | | |
| Elongation (per cent in 2 in.) | 22 | 22.5 | 25 | 31 | | | | |
| Reduction of area (per cent) | 68 | 69.5 | 74 | 80 | | | | |
| Creep strength 1 per cent in 10,000 hr (1000 psi) | | | 29 | 11.2 | 6 | | | |
| Creep strength 1 per cent in 100,000 hr (1000 psi) | | | | | | | | |
| Rupture strength 1000 hr—(1000 psi) | | | | | | | | |
| Rupture strength 10,000 hr—(1000 psi) | | | | | | | | |
| Oxidation (weight loss in grams per sq in. after 168 hr in air at the indicated temperatures) | nil | nil | nil | 0.04 | 0.06 | 0.35 | 0.91 | 1.53 |
| Linear thermal expansion (inches per foot—from 70 F to the indicated temperatures) | | 0.066 | | 0.087 | | 0.110 | | |

*Limited data available.

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- PRESSURE VESSELS
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- DRUMS
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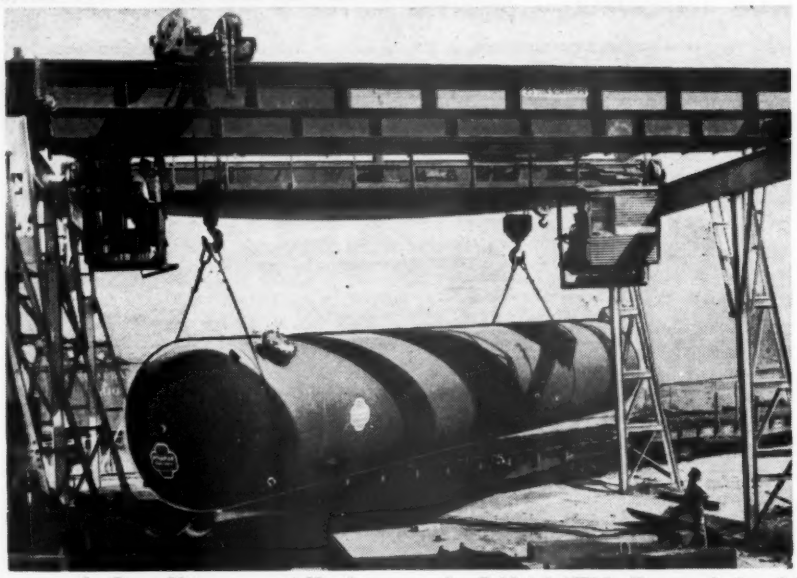
- ABSORBERS



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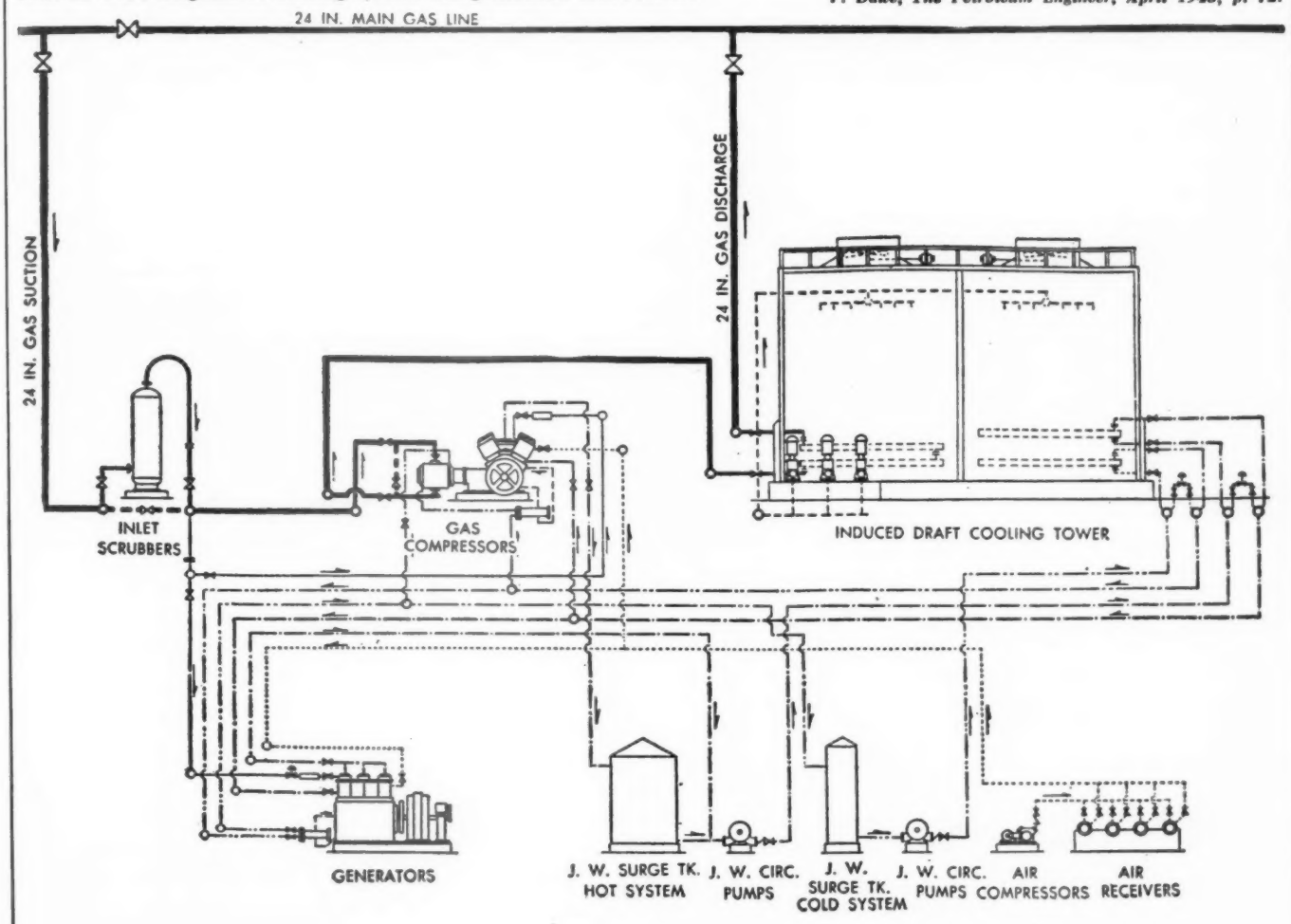
# DESIGN AND CONSTRUCTION OF GAS COMPRESSOR PLANTS

FIG. 2. Flow diagram of cooling system using induced draft tower. *From "Modern Compressor Station Design," by Harold F. Dawe, The Petroleum Engineer, April 1945, p. 72.*




*(6) One and two stage compression.* If the ratio between intake pressure and discharge pressure is much greater than from 4.5 to 5, the temperature of the gas becomes very high, which may effect harmfully the oil used to lubricate the compressor and, thereby, may result in damage to the cylinder walls and the valves. By the use of two-stage compression, with the gas passing through intercoolers between stages, an overall pressure ratio of up to 25 may be obtained without excessive temperatures developing in either cylinder.

If the need for two-stage compression is obvious, the work of compression should be divided as equally as possible between the two stages.

*(7) Pipe connections for compressor installations.* The flow of gas from a compressor cylinder varies from zero to a maximum with each complete revolution. Gas is taken into the cylinder during part of one stroke and is discharged during part of the next stroke, the exact amount taken in and pushed out being dependent upon the volumetric efficiency of the compressor cylinder. The rate at which the gas is taken in and discharged depends, of course, on the speed of the piston. Therefore, since the gas is not going in or leaving the compressor at a constant rate the average rate of delivery of gas should not be used to determine the most efficient size for suction and discharge lines. An assumption of constant gas flow from the compressor will result in the selection of too small sizes of pipe that, in turn, will be responsible for the development of a greater drop in pressure between the compressor and the header than would take place by the use of pipe of larger diameter. The pressure drop, brought about by undersized piping, frequently may be the reason why an otherwise correctly designed compressor plant will not deliver its rated capacity or to do so must operate under an overload.

All connections to the discharge cylinder should be flanged so that the cylinder can be removed without disturbing the pipe system, and all discharge pipes should be so anchored or supported to reduce vibration, resulting from the pulsating discharge of the compressor, to a minimum.

*(8) The cooling system.* According to Thiel[9], an inadequate or unsuitable cooling system for the cooling of internal-combustion engines and gas compressor cylinders has increased the maintenance cost of compressor stations substantially. Plans, therefore, for an effective cooling system are of great importance.

There are three general methods of constructing a closed cooling system. One is to install tubes through which the treated cooling water is led near the bottom of an evaporating cooling tower. The second is to use a shell-and-tube type heat exchanger, flowing the raw water through the tubes and the treated water around them. The third is the radiator type that has proved to be advantageous in small plants situated in arid regions. The selection of whichever system is used depends upon the general layout of the station and its situation in regard to the water supply.

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NOTE: References are shown on the last sheet in this series.

Taken from the article "Design and construction of compressor plants," by Paul D. Torrey that was presented before American Petroleum Institute Southwestern District Division of Production, Shreveport, Louisiana, May 17 and 18, 1946, revised in 1947, and published in *The Petroleum Engineer*, December, 1947, pages 108 to 126, inclusive.

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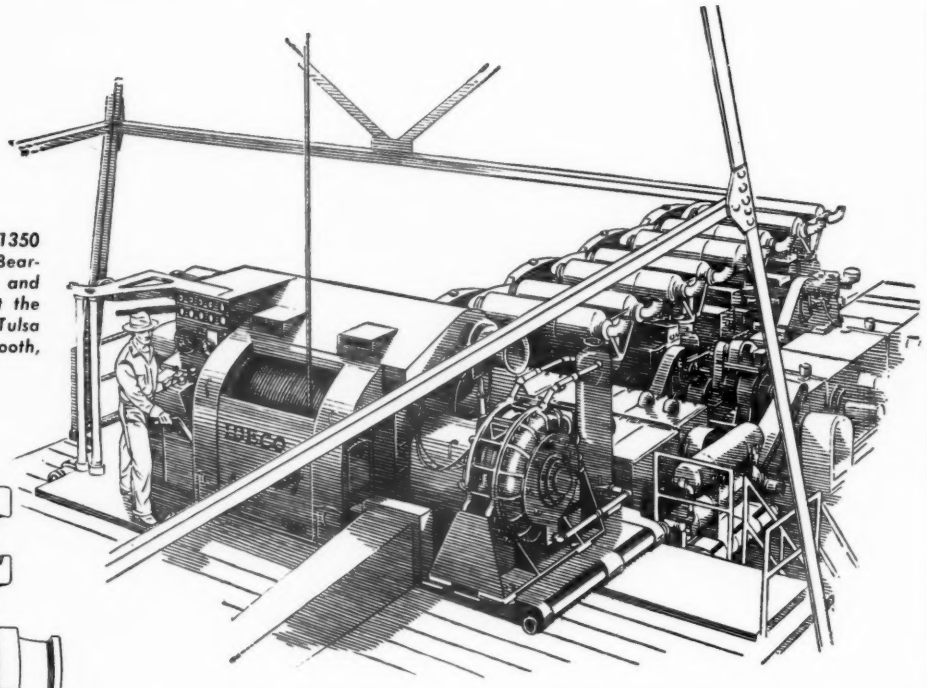


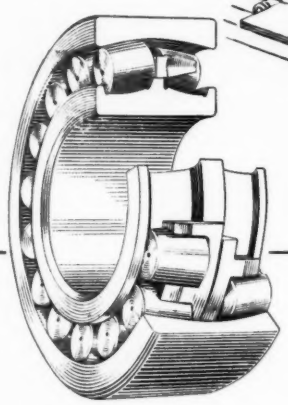

**... operating and maintenance economies are important advantages of these heavy-duty, self-aligning bearings.**

IN THE DRAW-WORKS, transmission and compound drives of Ideco Power Rigs, Torrington Self-Aligning Spherical Roller Bearings provide high radial capacity for dependable performance and long service life. Reduced power consumption and higher speeds are among the advantages made possible by these precision bearings. Self-aligning under deflection, they require no adjustment. The two-directional thrust feature assures axial stability of shafts, for proper meshing of gears and drives with end play eliminated.

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# PROPERTIES OF INTERMEDIATE ALLOY STEELS AT ELEVATED TEMPERATURES

2. *Composition.* All specifications permit some latitude in composition, which is inevitably reflected in a range of mechanical properties, both at atmospheric and elevated temperature.

3. *Manufacturing practice.* In general, coarse grained silicon killed steels have higher creep and rupture strengths than the fine grained aluminum killed steels, although the coarse grained steels are more susceptible to strain aging and blue brittleness in the temperature range of 400-600 F.

Furthermore, some of the steels are manufactured to several specifications as listed below. The individual compositions and room temperature properties are shown in these specifications. Maximum allowable working stress, corresponding to the composition in question, will be found in the ASME Table U-2 of the Code for Unfired Pressure Vessels.

**ASTM specifications**

*0.5 Mo steel* (Table 1)
A204-46, Grades A, B, and C
A234-44
A182-46, Grade F1
A161-46
A209-46, Grades T1, T1A, T1B
A206-46, Grade P1

*1.0 Mo steel* (Table 2)
None

*1.25 Cr-0.50 Mo steel* (Table 3)
A199-46, Grade 1
A200-46, Grade 1
A213-46, Grade T11
A158-46T, Grade P11

*1.75 Cr-0.75 Si-0.75 Mo steel* (Table 4)
A199-46, Grade 3
A200-46, Grade 3
A213-46, Grade T3
A158-46T, Grade P3a
A182-46, Grade F3

*2.0 Cr-0.5 Mo steel* (Table 5)
A199-46, Grade 4
A200-46, Grade 4
A213-46, Grade T14
A158-46T, Grade P3b

*2.0 Cr-1.25 Si-0.5 Mo steel* (Table 6)
None

*2.5 Cr-0.75 Si-0.5 Mo steel* (Table 7)
A199-46, Grade 2
A200-46, Grade 2

*2.25 Cr-1.0 Mo steel* (Table 8)
A199-46, Grade 6
A200-46, Grade 6
A213-46, Grade T22

*3.0 Cr-1.25 Si-0.5 Mo steel* (Table 9)
None

*3.0 Cr-1.0 Mo steel* (Table 10)
A199-46, Grade 5
A200-46, Grade 5
A213-46, Grade T21

NOTE: References are shown on the last sheet in this series of tables.

Taken from the exclusive article, "Intermediate alloy steels at elevated temperatures," by R. F. Miller, Research and Technology Division of Carnegie-Illinois Steel Corporation, published in *The Petroleum Engineer*, January, 1948, pages 178 to 189, inclusive.

**TABLE 5. 2 per cent Cr, 0.5 per cent Mo—properties at elevated temperatures*. Composition range covered by specifications (per cent).**

| C | Mn | Si | P | S | Cr | Mo |
|---|---|---|---|---|---|---|
| 0.15 max | 0.30/0.60 | 0.50 max | 0.030 max | 0.030 max | 1.75/2.25 | 0.45/0.65 |

| Property | Temperature, F | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 700 | 800 | 900 | 1000 | 1100 | 1200 | 1300 | 1400 |
| ASME Maximum allowable stress (1000 psi) | 12.0 | 11.6 | 10.0 | 5.85 | 2.2 | | | |
| Tensile strength (1000 psi) | 65 | *58.5-64* 62 | *53-61.5* 57 | *46.5-53.5* 49 | *38-44* 40 | *25-30* 28.5 | *16-20* 18.5 | *10-11* 10.5 |
| Yield strength (1000 psi) | | 25 | 22.5 | 20 | 18 | 15 | 11 | 7.5 |
| Elongation (per cent in 2 in.) | | 28 | 32 | 36 | 43 | 59 | 71 | 84 |
| Reduction of area (per cent) | | 65 | 71 | 77 | 84 | 88 | 92 | 96 |
| Creep strength 1 per cent in 10,000 hr (1000 psi) | | | *18.8-20* 19.2 | *9-12.8* 10.5 | *5-6* 5.5 | *3-3.5* 3.2 | | |
| Creep strength 1 per cent in 100,000 hr (1000 psi) | | | 14.3 | *5-6.2* 5.5 | *3.2-4* 3.5 | *0.8-1.6* 1.2 | | |
| Rupture strength 1000 hr—(1000 psi) | | | | | | | | |
| Rupture strength 10,000 hr—(1000 psi) | | | | | | | | |
| Oxidation (weight loss in grams per sq in. after 168 hr in air at the indicated temperatures) | nil | nil | nil | 0.03 | 0.06 | 0.29 | 0.63 | 1.04 |
| Linear thermal expansion (inches per foot—from 70 F to the indicated temperatures) | | 0.066 | | 0.087 | | 0.110 | | |

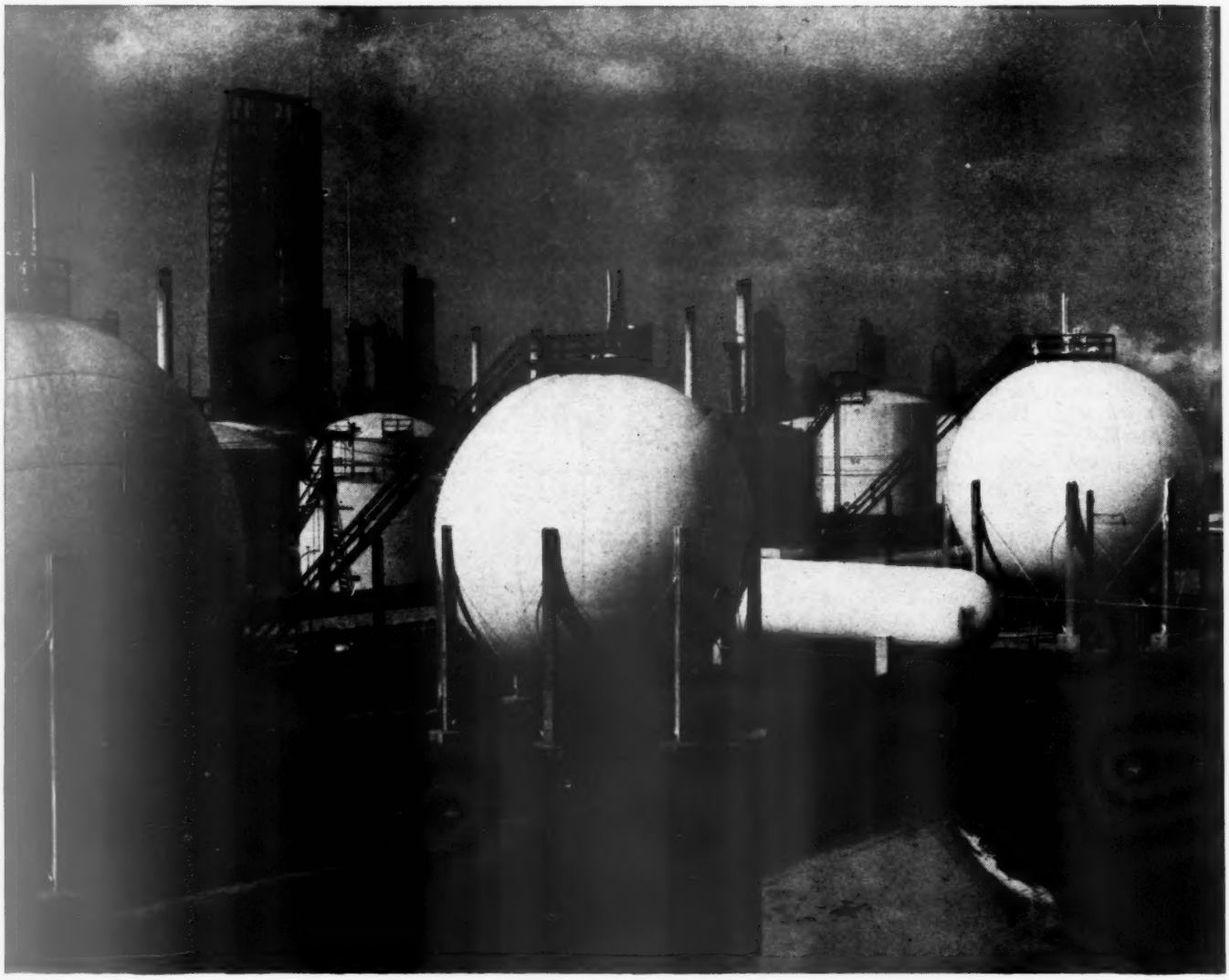
*Values in italics show spread of available data, and accompanying single values are a conservative average of the data. Single values, only, represent limited data.

**TABLE 6. 2 per cent Cr, 1.25 per cent Si, 0.5 per cent Mo steel—properties at elevated temperatures*. Composition range covered by specifications (per cent).**

| C | Mn | Si | P | S | Cr | Mo |
|---|---|---|---|---|---|---|
| 0.15 max | 0.50 max | 1.0/1.4 | .030 max | .030 max | 1.75/2.25 | 0.45/0.65 |

| Property | Temperature, F | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 700 | 800 | 900 | 1000 | 1100 | 1200 | 1300 | 1400 |
| ASME Maximum allowable stress (1000 psi) | | | | | | | | |
| Tensile strength (1000 psi) | 67.5 | 62.5 | 56.0 | 48.0 | 37.0 | 27.0 | 18.0 | 11.0 |
| Yield strength (1000 psi) | | 29 | 25.5 | 22.5 | 19.5 | 15 | 10.5 | 6 |
| Elongation (per cent in 2 in.) | | 31.5 | 35 | 42 | 49 | 60 | 32 | 100 |
| Reduction of area (per cent) | | 70 | 74 | 80 | 86 | 92 | 96 | 98 |
| Creep strength 1 per cent in 10,000 hr (1000 psi) | | | 13.6 | 7.5 | 4.5 | 3.5 | | |
| Creep strength 1 per cent in 100,000 hr (1000 psi) | | | 10 | 5.6 | 2.4 | 1.4 | | |
| Rupture strength 1000 hr—(1000 psi) | | | 33 | 20 | 11 | 6.4 | | |
| Rupture strength 10,000 hr—(1000 psi) | | | 27 | 15 | 7 | 4.2 | | |
| Oxidation (weight loss in grams per sq in. after 168 hr in air at the indicated temperatures) | nil | nil | nil | 0.01 | 0.02 | 0.03 | 0.04 | 0.09 |
| Linear thermal expansion (inches per foot—from 70 F to the indicated temperatures) | | 0.006 | | 0.087 | | 0.110 | | |

*Limited data available.



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## Personnel changes

J. W. Bozeman has been appointed vice president and assistant general manager of the Tuboscope Division of Tubular Service and Engineering Company, Houston, Texas. Bozeman has been stationed in Houston as sales manager for Tuboscope for the last three years, prior to which time he served the company as divisional manager for Louisiana and Mississippi.

Clint Lewis, former divisional manager of the Louisiana-Mississippi territory with headquarters at New Iberia, Louisiana, has been promoted to the position of assistant sales manager and was transferred to the Houston headquarters.

J. W. Bozeman

Clint Lewis

Harry Bozeman

B. H. Pickard

Harry Bozeman, former branch manager of the South Texas district, Beeville, Texas, replaces Lewis.

Concurrent with the formation of the new Gulf Coast division of the company, comprising the former Houston district and South Texas district, B. H. Pickard was appointed to the position of Gulf Coast divisional manager. Pickard formerly was in charge of the Houston district.

## Sales manager

R. B. Rennaker, affiliated with the radio industry for the last 25 years, has been appointed sales manager of the mobile radiotelephone division of Federal Telephone and Radio Corporation, Clifton, New Jersey, manufacturing associate of International Telephone and Telegraph Corporation.

Rennaker was formerly associated with both the Mutual and Columbia Broadcasting systems in addition to serving in Washington, D. C., with the war department. He joined Federal in 1945 as broadcast equipment sales engineer, and subsequently became associated with Collins Radio Company for one year and rejoined Federal recently to assume his new duties in FTR's sales force.

## Honeywell promotes

A number of personnel changes including new regional, branch, and division managerships have been announced by the Minneapolis-Honeywell Regulator Company.

Kent L. Wilson has been promoted to manager of the southwest region with headquarters in Dallas. Since 1944 he has been Detroit branch manager. Wilson follows Karl W. Schick who has resigned from the company to take over the agency of the Bryant Heater Company in Dallas.

Succeeding Wilson in Detroit is T. S. Carley who has been sales manager of the stoker and wholesale divisions at the home office.

Walter J. Baak, who has been Moduflow sales manager of the midwestern region, with headquarters in Chicago, has been promoted to sales manager of the wholesale division.

G. M. Kingsland, who has been heading sales activities of the company's control devices and specialties departments, is taking over new duties in the heating controls division. His immediate responsibility will be to head up sales activities of the stoker controls division.

William S. Robards has been appointed Milwaukee branch manager. He succeeds L. C. Johnson who died after a short illness in May of this year. Robards has been in the Milwaukee office since 1944 in charge of industrial division sales.

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Swamp areas increase corrosive action that must be met with heavier applications of HILL, HUBBELL factory applied pipe protection—Your assurance of long service life for your pipe is the HILL, HUBBELL imprint on the heavy kraft paper wrapper.
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Available in these temperatures (°F)

| | | | |
|---|---|---|---|
| 125 | 275 | 500 | 1100 |
| 138 | 288 | 550 | 1150 |
| 150 | 300 | 600 | 1200 |
| 163 | 313 | 650 | 1250 |
| 175 | 325 | 700 | 1300 |
| 188 | 338 | 750 | 1350 |
| 200 | 350 | 800 | 1400 |
| 213 | 363 | 850 | 1450 |
| 225 | 375 | 900 | 1500 |
| 238 | 388 | 950 | 1550 |
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## Sales manager

The appointment of Walter G. Schlichting as sales manager of the heating, cooling and air conditioning division of the Young Radiator Company has been announced by John J. Hilt, vice president. Schlichting had a long association in the sales and engineering field in heating, cooling, and air conditioning and prior to joining the Young Radiator organization was manager of the air conditioning division of Clarage Fan Company, Kalamazoo, Michigan.

W. G. Schlichting

## In charge sales

Election of J. Douglas Darby as vice president in charge of sales of Carnegie-Illinois Steel Corporation has been announced by C. R. Cox, president of this United States Steel subsidiary. He succeeds Thomas J. Hilliard, who resigned.

J. D. Darby

A native of Philadelphia, Darby received his college education at Yale University, graduating in 1919, following service as a Field Artillery officer in World War I.

First employed as a slagman in the open hearth department of the Alan Wood Steel Company, Darby rose through various positions in his 20 years' service there to become general superintendent and later assistant to vice president of sales. He joined the sales department of Carnegie-Illinois in 1939 and that year was made district manager of sales in Philadelphia. He moved to Pittsburgh in 1945 as general manager of sales for the company.

## Factory servicing

In order to facilitate the servicing of the great number of Beckman instruments in use throughout the eastern and middle-eastern areas, National Technical Laboratories, manufacturers of Beckman instruments, has established its own factory servicing headquarters at 9 South Clinton Street, Chicago, Illinois. George R. Kinkaid, midwestern representative for National Technical Laboratories, is in charge.

## Made board chairman

A. G. Stoughton, president of Midwest Piping & Supply Company since its formation in 1920, was elected chairman of the board as well as president at a recent meeting of directors at the company's executive offices in St. Louis. The office of board chairman was vacated recently through the death of Hugo F. Urbauer. Walter R. Mayne, St. Louis attorney, was elected a director.

## Assistant general manager

Appointment of Lenvik Ylvisaker as assistant general manager of Koppers' Piston Ring Division is announced by Allen W. Morton, vice president and general manager of the division.

All manufacturing operations of the Piston Ring Division, which makes American Hammered Piston Rings, are in Baltimore, and Ylvisaker will move there from Pittsburgh where he has been assistant production manager for Koppers.

At the same time, the appointment of Dr. T. C. Jarrett as manager of the engineering and development department of the division was announced. He has been chief metallurgist of the division since 1941.

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Mass production methods bring you Jensen pumping units for a lower initial cost. But that's only part of the Jensen story.

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Did you hear about the couple driving across the Mojave desert? In the distance they saw a tiny black speck which, when they approached it, turned out to be a man wearing only his swimming trunks.

The man hailed them and said, "How far is the ocean?"

Somewhat surprised, the couple explained that the ocean was a few hundred miles away, on the other side of California.

"Good Lord," said the man, staring at the sandy waste, "what a beach!"

She was the kind of girl who wore the kind of dresses that kept everyone warm but her.

"Do you object to petting, Alice?"

"That's something I've never done, Bill."

"Never petted, Alice?"

"Never objected, Bill."

Farmer Corntassel retired and moved to town.

In the morning, after spending the first night in the new home, his wife said: "Well Pa, hain't it about time you was getting up to build the fire?"

"No, siree," replied the old gent, "I'll call the fire department. We might as well get used to these city conveniences right now."

A neighbor, passing the cabin of a mountaineer, had the bad fortune to run over and kill the mountaineer's favorite dog. He went into the house and told the man's wife what had happened and how sorry he was. The owner of the dog was out in the fields, and the motorist decided he had better go out and tell him of the accident, too.

"Better break it to him easy like," said the wife. "First tell him it was one of the kids."

*Mother* (to the twins): I'm glad boys, you're sitting so quietly and not disturbing daddy while he takes his nap.

*Twins:* Yes ma—we're watching his cigarette burn down to his fingers!

*House Dick* (on phone): Are you entertaining a man in your room?

*Tootsie:* Just a minute—I'll ask him!

Dotty and her husband were always ribbing each other. Knowing her husband was within easy earshot, she winked at a friend and said. "My husband drinks like a fish."

Instantly hubby stuck his head in the door: "I could say my wife drives me to it, but I'm not going to run her down. All I'll say is that I pawned the kitchen stove once and she didn't miss it for three weeks!"

At a muddy crossroad corner in the deep South is a sign that reads:

"Choose your rut carefully—you'll be in it 20 miles."

"I tell you," the old lady said firmly to the bell boy, "I will not have this room. I'm not going to pay for a closet without a window. Just because I'm from the country . . ."

"Get in lady, get in," the bell boy said wearily, "this isn't your room. It's the elevator."

I didn't want to marry her for her money, but I didn't know how else to get it.

*Prospective Roomer:* The window is very small. It wouldn't be much good in an emergency.

*Landlady:* There ain't gonna be none, mister. My terms are cash in advance.

"You old drunken beast. If I were in your condition, I'd shoot myself."

"Lady, if you wash in my condition, you'd mish."

The family had overslept and the lady of the house woke with a start to the clanking of cans down the street. She remembered that the garbage had not been put out, and raced down to the front door, struggling into a robe, with her hair in curlers, and looking sleepy-eyed.

"Yoo hoo," she called. "Am I too late for the garbage?"

"No," shouted the collector. "Jump right in."

"What's an optimist?"

"A guy who thinks his wife has stopped smoking cigarettes when he finds cigar ashes in the house."

*Patient:* Will I know anything when I come out of the ether?

*Nurse:* Well, that's expecting an awful lot from an anesthetic.

*Clerk:* That will be $1.50 for the nylon stockings and 5c for the tax.

*Customer:* Never mind the tacks, I'll fasten 'em to my girdle!

*She:* Don't you love driving in the country?

*He:* Yeah, but we ain't out far enough yet!

Two Indians obtained a room in a big-city hotel. Two days elapsed and the manager, having heard nothing from his guests, became worried and opened the door with his master key. He found a tepee set up in the room, and one of the Indians sitting in front of it smoking a pipe.

"How," said the Indian.

"Where's your friend?" asked the manager.

"In there," grunted the Indian, indicating the bathroom.

The manager looked in the bathroom and found the other Indian on the floor with an arrow in his heart.

"Good gosh, who killed him?" asked the manager.

"Me, I killed him," grunted the Indian.

"Why did you do it?"

"Him spit in spring!"

....AND AFTER THE WICKED GIANT BURIED THE TREASURE DEEP DOWN IN THE GROUND, HOW DO YOU SUPPOSE THE HERO FOUND IT?
BEDTIME STORIES
RAN A LANE-WELLS RADIOACTIVITY WELL LOG, OF COURSE!!
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***For float indicators or Tubular Gage Glass***

Specially die-cast close-grained metal. Copper and molybdenum plated.

Clear reading with raised numerals and graduations. Accurate to .001 inch. Corrosion-proof. Last a lifetime.

Numerals read up or down, as desired, in feet, either decimal scale to 0.01 feet or inches to 1/8".

Furnished complete with numerals, mounting screws, ready to install. Numerals available up to 40 feet.

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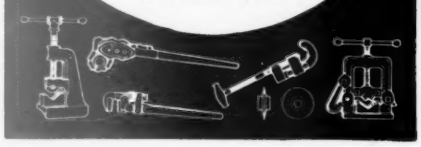


## Division manager

F. D. Smith, Oil Well Supply Company general sales staff manager in the company's headquarters at Dallas, Texas, has been named manager of that U. S. steel subsidiary's Gulf Coast division with headquarters at Houston, Texas.

F. D. Smith

A veteran of 20 years' service with "Oilwell," Smith joined the company in March, 1928. He served variously as storeman, field salesman, and district manager in Kentucky and Tennessee until 1933 when he transferred to Oil City, Pennsylvania, with the eastern division sales department. In April, 1935, he has made district manager for Michigan and in January, 1941, he went to Mt. Vernon, Illinois, as manager of the eastern division. He remained in that position until January, 1944, when he moved to "Oilwell's" headquarters in Dallas as assistant to general manager of sales and later assistant general manager of sales. He was appointed general sales staff manager January 1, 1948.

The Gulf Coast division includes all states bordering on the Gulf of Mexico and Mexico.

Smith succeeds Paul H. Shepherd. who is transferring to the company's treasury department at Dallas.

## Elected vice president

Election by the board of directors of Carl Brockway to a vice presidency of Thermoid Company is announced by President Fredric E. Schluter. The action was taken at the first meeting following the annual election of the board.

Prior to his becoming associated with Thermoid in 1941, Brockway was president and general manager of Worldbestos Corporation, a brake lining manufacturing concern. In his new capacity, Brockway will be responsible for all production of brake lining. clutch facings, and other friction materials.

## Correction

In the article "Safe Practices in Using Wire Rope" by Don Attaway, The Petroleum Engineer, May, 1948, beginning on page 254, two clarifying corrections should be made.

On page 258, second column, this statement is made: "(1) If a rope is used for hoisting material only and there are no broken wires, a rope may be used *until it is about 65 per cent of its original diameter.*" The words in italics should have read: "*until the thickness of the outside wires is worn to about 65 per cent of their original diameter.*

In the same column there also appears this statement: "(3) If a rope is used for hoisting persons it should be replaced when in the judgment of a qualified inspector its strength is impaired and in any event *when the thickness is one-half the original diameter* even though there are no broken wires."


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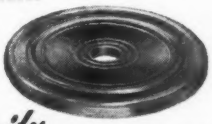

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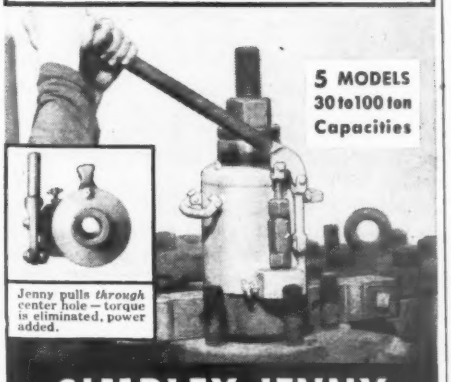


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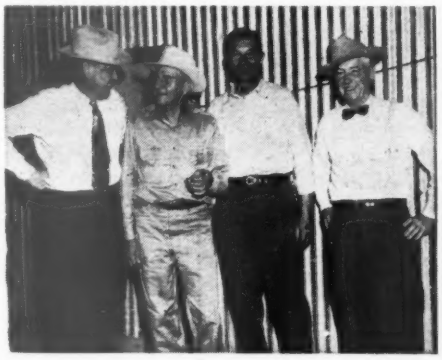
Again, the italicized words should have been: "*when the outside wires are worn to a thickness of one-half their original diameter.*"

In other words, the reduction mentioned as being due to wear refers to the diameter of the outside wires only and not to original diameter of the rope.

## Cameron celebration

A new Cameron Iron Works store was opened at Odessa, Texas, on May 5, and the West Texas division manager, Roy Davis, was host to approximately 750 oil and supply men from the surrounding country. Barbecue and refreshments were served by the Odessa Chuck Wagon Gang.

Cameron officials and employes who attended the celebration were E. L. Lorehn, vice president and general manager; Ralph McCullough, secretary-treasurer; Bob Farmer, assistant sales manager; J. M. (Red) Teague, service manager; Homer Brown and Gene Teer from Houston; Merle Hooks from Hobbs, New Mexico, Pud O'Connor, Jake Dyer, and Bubba Barr from Odessa assisted Roy Davis with the entertainment.



Ralph McCullough, left, Red Teague, Roy Davis, E. L. Lorehn

## Sales engineer

The appointment of E. E. (Spike) Spicer as petroleum sales engineer was recently announced by V. C. Genn, general sales manager of the Detroit Diesel Engine Division, General Motors Corporation. Spicer has many acquaintances in oil field circles, having been associated with the petroleum industry since 1933. His well rounded experience ranges from pumper and roustabout to the sale and servicing of diesel engines.

Spicer will operate out of the company's petroleum industry sales office under Arch F. Campbell.

## Sales representative

In conjunction with an expanding sales organization, Fred Harmon Seaver has joined the Federal Telephone and Radio Corporation, Clifton, New Jersey, associate of International Telephone and Telegraph Corporation, as sales representative covering the Far West territory for Federal's mobile radio division.

Seaver for some years has been active in engineering design and research work on mobile radio equipment.


**Effortless way to reduce Pumping Costs!**

**Specify DARCOVA**

**. . . the ORIGINAL composition valve cups, seating cups and rings**

• Precise control of all materials and processes from lab to well means exceptional resistance to wear and deterioration . . . fewer pulling jobs! • Different textures, scientifically developed, fully proved, give peak efficiency and longer flex-life at *any* depth! • Accurately controlled sizes for any make or size pump . . . no misfit inefficiency! • Ask for *genuine* Darcovas at your supply store.

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THE ORIGINAL COMPOSITION CUP

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CUSHION SEVERE SHOCKS
CHECK DISTORTION
EXTEND LIFE OF V-BELTS,
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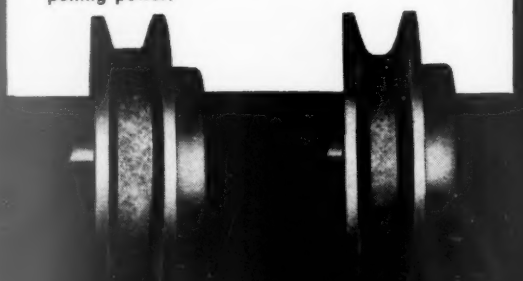
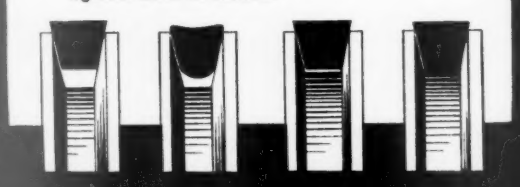
Most V-belt installations operate under conditions where belt tension changes from pull to lag several hundred times per minute. By cushioning strains and stresses, Baroid V-Belt Shock Absorbers reduce belt distortion and prolong the life of belts, pulleys, and bearings. Baroid V-Belt Shock Absorbers, reduce slippage to provide maximum pulling power.



1. V-Belt in normal position in groove without shock absorber.
2. V-belt distorted under stress.
3. V-belt with Baroid V-Belt Shock Absorber in normal position.
4. V-belt under stress. Baroid Shock Absorber firmly supports belt, assures even pull of belt against sides of sheave.



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# Petrolic Personalities

By DICK SNEDDON

## THE NOMADS' SPECIAL

At considerable expense, and despite the bother of the thing, we have decided to reveal to an anxiously awaiting public, as nearly as we can recollect them, the sordid details of the terrific buffeting to which we were recently subjected by a cruel fate, and an ebullient Peruvian, named Bob Block. It all began on May 12 when in a moment of madness we boarded the Nomads' Special in Los Angeles and wended our way in a series of agonizing jolts to the International Petroleum Exposition at Tulsa, Oklahoma. It ended when approximately two weeks later we crawled on hands and knees from this same Nomads' Special—a broken and a beaten man.

When we first entered the Union Depot at Los Angeles and ran into a young fellow by the name of Frosty Martin we were bubbling over with the zest for adventure, and when in due course we were assigned to a drawing room with Paul Cavins and Bob Block we realized that we shouldn't allow any more of our zest to bubble over because we would need every bit of it. These two industrial behemoths together weigh slightly less than a D-8 bulldozer, while we are of the dainty type, having a torso somewhat resembling in shape and dimensions one of these glazed turkeys you see hanging in the Chinese butcher shops up in San Francisco. In a drawing room, approximately 8 feet by 4, it was only by constant watchfulness and an inherent agility, for which we are devoutly thankful, that we avoided being caught between these two Titans and ground to a quivering pulp. While in the dark of night we personally lay on a narrow shelf and were shuttled violently from end to end by an engine that had a nasty impediment in its reach, our roommates indulged in a snoring duet of staggering intensity. By the sheerest good fortune they snored alternately so that the vibrations neutralized each other and the train was able to stay on the tracks.

The inevitability of night time made it a little difficult to enjoy the day time, but there were some right nice people on deck, and for a sizable consideration they taught us lovely games with cards and colored disks. From old Albion no less came Leonard Dawson, general manager of Oil Well Engineering Company, Stockport, an affiliate of National Supply, bringing an entirely new card game, which he called Brasso. It took the Special by storm, and in no time at all Earle Boggess, Don Hansen, Larry Miller, Kinzie Miller, Jack Ballagh, and yours truly were performing so expertly that the original propounder was "being took" in no uncertain fashion. We might mention in passing that L. S. Dawson is a personable chap who made a nice impression on every one he met out here. He has been in the oil industry for 26 years, and tells us that his firm manufactures a considerable portion of the National line, plus many specialties under license for Baker Oil Tools, Parkersburg, American Iron Works, Chiksan Company, Patterson-Ballagh, Lee C. Moore, and Baash-Ross.

We rather enjoyed his gentlemanly "I'll go quietly," when he lost a game, in contrast with the shotgun expletive that was emitted by most of the American boys under the same circumstances. In his home bailiwick, when not playing Brasso, he finds diversion in gardening. In fact, when we casually mentioned to him that there were more than 4000 Poles in New York, he clucked, "My! My! What a place to raise dahlias!"

Not all the people on the train were of the super-boisterous genera. There were two well behaved lads from Cummins Diesel—Bob Vaughan and Ed Bonette who went to bed almost every night and yet seemed to enjoy themselves. They even took home 15 gallons worth of 5-gallon hats for their children, regardless of the fact that this is no time to be jumping up the overhead. Nonetheless, they were good citizens and they helped no end to add joviality to the jaunt. Then there were Paul Connelly and Emmett Lawless, a pair of erst-

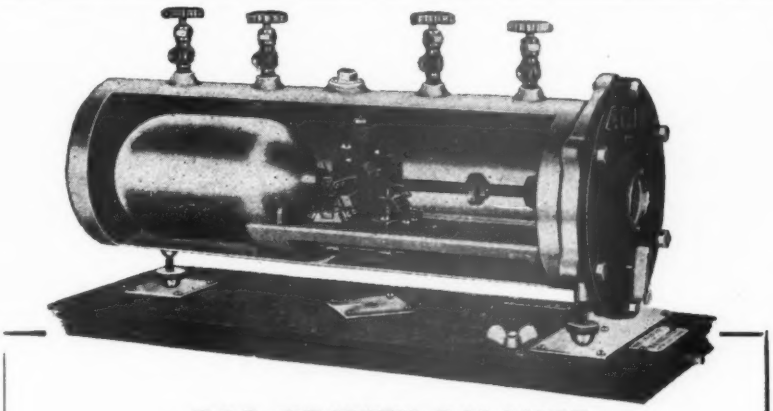
while Hibernians several generations removed, who now devote themselves unstintingly to the welfare of General Motors Corporation. Paul is general manager on the Pacific Coast, and lives in San Marino, where the landscaping of his fine home furnishes him with a constant element of surprise. The thing that surprises him most is what comes up from what he plants. Emmett is a displaced Michigander who manages G. M.'s Bakersfield store between hunting trips. We understand that he is the most confirmed nimrod since the passing of Daniel Boone. Big game is his favorite quarry, and he is reputed to have stalked an elk so quietly that before it even knew he was in the vicinity he was close enough to see the tooth on its watch chain. These lads had the unquestionable privilege of occupying the same bunkhouse on the Special as Frosty Martin, president of the Long Beach Harbor Commission, and one of the most abstinent men in the oil business—he lives on cribbage and white wine. Frosty is a perennially young individual who has in a large way been responsible for making Long Beach one of the richest oil towns in the United States. We emphasize his present youthfulness, despite some 45 years in petroleum, because when a patrol of comely ladies, Daughters of the Nile—from El Paso, Texas, boarded the train in the custody of a good looking Queen Bee, Frosty almost immediately became 20 years younger, and it was all we could do to keep him out of their formation drills thenceforth.

On the eastward trip, besides the indefatigable Bob Block, we had another ex-Peruvian, Arnett Norcott, recently retired general manager of International Petroleum Company, who went out to Colombia for Tropical in 1926 as assistant superintendent of the gasoline department and transferred to Peru with IPC in 1929. We are told that he and Bart Myers are planning a trip to Hawaii after the first of the year to see if there is anything to this grass skirt business. Arnett now makes his home in Whittier and indulges to the limit a propensity for games of all sorts. He loves golf, poker, and is especially fond of horses, particularly the ones that run first when they are carrying his mazuma on their lovely soft noses.

Here, perhaps we might pause to dilate at greater length on Roberto the Block, who is without doubt the most tireless individual we have run across in many a long day. Thoroughly good natured and stronger than a Percheron, the only time he sleeps is when it can't be avoided, and then he does it entirely with his nose. All joking aside, Bob, now manager of C & C Tool Corporation, the development branch of the Cavins Company, is a grand person. He also went to Colombia first in 1926 with Tropical, and transferred to Peru with IPC in 1933. When he left to join Cavins organization in 1947 he was drilling superintendent for IPC, and one of the best known and best loved men in foreign fields. Long before we knew Bob personally we had heard a hundred travelers extol his virtues. It was always the same story of a big-hearted guy down there in Peru who reached out a helping hand to every visiting tenderfoot—took him in tow, pointed out the procedures and the pitfalls, and generally made life in a strange environment much more comfortable than it could otherwise have been.

On the way home we picked up a third ex-Peruvian, to wit, Lee Chisholm, once assistant drilling superintendent for IPC, now in charge of sales and service for Shaffer Tool Company, up Ventura way. Lee was on the discovery well in the Turner Valley field in Alberta, Canada, back in the early 20's. He was then with Imperial Oil, Ltd., but later was induced to go to Colombia with Tropical and thence to Peru. He came back to the United States in 1947 after 21 years in foreign service to enter the employ of Shaffer Tool Company, and has since been busier than a corkscrew at an oil convention. Lee's principal amusement is plowing with a niblick, or "golf" as it is sometimes known. In this endeavor, we are told, his excavations have been tremendously helpful to certain archaeologists who were down in Peru searching for a lost race. All we have to do to find a lost race is put two bucks on a horse's nose and await developments.

Among other interesting passengers on the Nomads' Ark were Henry Pullman, the Marco Polo of the equipment industry, and a cosmopolitan if there ever was one. We never saw

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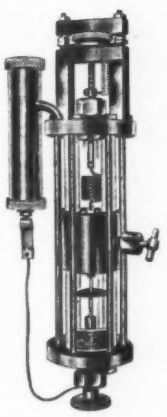
This testing equipment is used in connection with gas measurement by orifice meter.



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**Houston Office Temporarily Discontinued**

him quite so much at home as he was in International House at the Exposition, surrounded by delegates—male and female—from virtually all the countries of the world, speaking Sanscrit one minute, Gum Arabic the next, then branching off into Spinach, Cantonese or Kaffir, as the occasion demanded. And all of this mark you without the loss of a single circumflex accent. It was an amazing display of laryngeal facility, if we may become polysyllabic, and we'd like to see anyone try to stop us.

Also numbered among the near greats in this strange aggregation of pullmanites was Earle Boggess, the Baker Oil Tool man about town whose platform deportment we have always stoutly admired. Earle is a gentlemanly sort of chap, and the smoothness with which he presents his performers on Nomad meeting nights is an example after which stumbling neophytes should pattern their futile efforts. If you plan to make Brasso your career, better talk it over with Earle. He is undoubtedly one of the best informed men in America on this fascinating pursuit, but watch out—it may cost you.

Trading bunks with your scribe (loud laughter) and Bob Block in Drawing Room A was Paul Cavins, the modest president of Cavins companies, an Illinoisian who migrated to Long Beach, California, graduated in accounting from USC, and received his petrolic baptism up around Bakersfield, where for a while he practiced as an oil accountant. In 1929 he started the Cavins Company for the purpose of developing a line of production tools, and had soon so far modernized well cleanout methods that they were much more effective in much less time. The first unit on which he concentrated was a hydrostatic bailer, from which has sprung an imposing array of interesting devices utilizing the hydrostatic principle. Altogether the Cavins group controls some 50 related patents. At the moment the big excitement is a junk snatcher, and it is a honey, of which we shall tell more at the proper time and in the proper place. The Cavins Company offices and factory, serving California, Rocky Mountain states, and foreign territories, are in Long Beach. Corporation headquarters, serving Mid-Continent and Gulf Coast, are in Houston, Texas. A unique pipe testing service is carried on by C & C Tool Corporation, under the general management of Bob Block. And just to wind up this bit of circumlocution, Paul returned from IPE barely in time to attend the wedding of his son— a prospective architect. Also, in case you don't know, he is a brother of Omar, Standard of Cal's Valley Division production biggie, and possesses what is perhaps the finest hook in western golf—his drives from the tee have been known to swing wider to the left than Henry Wallace.

Back in Compartment E, playing foster father to Don Hansen, the pleasant young O & G J advertising hand, was Jack Ballagh. Jack spent the forepart of the voyage looking for a man who *thought* he could play pitch but couldn't, and finally gave up when he ran into Ralph Clemons, a player who *said* he couldn't but could. After that, Jack became a Brasso convert, and in no time at all was playing with a distinct cockney accent. He was the prime instigator of a popular movement to adopt the game officially and retitle it "Nomad" instead of Brasso. Personally, when we lose six bits in a card game, the pain is so excruciating that we have no interest in the name of the game. And veering slightly here, Jack is the author of a volume that we believe might well be accepted by some publisher of business books. It is a compendium of policy decisions on a wide variety of problems of the type that are ordinarily encountered by executives of medium and small businesses. The Ballagh opus would be immensely helpful to young adventurers in organized enterprise, and may yet become a best seller. Hope he has better luck than we did, however—once we wrote a swell story called David Copperfield, only to find that the thing had already been done by a guy named Dickens. Disgusting!

Down the corridor a piece from the Ballagh boudoir were that inseparable pair of exporters—Bob Eiche and Tom Martin, trying to prove to a snug coterie of friends by application that in poker a good deal depends upon a good deal. After we landed in Tulsa we glimpsed this duo at rare intervals, usually in the company of distinguished foreigners at International House, or strutting majestically among the exhibits,

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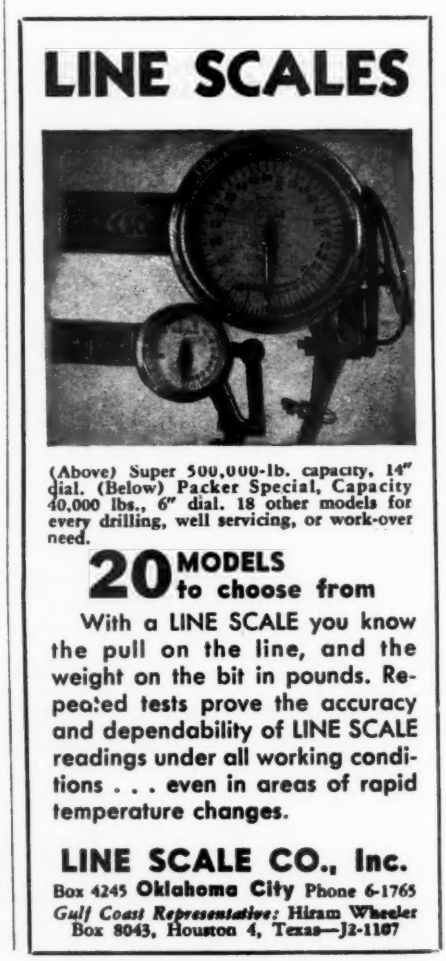
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flicking the debris with supercilious walking sticks, and looking themselves more like a couple of European dignitaries every minute. Another exporter of consequence who braved the rigors of the Nomads' Special was the swashbuckling Roland Smith who has rocketed to fame during the past few years with all the speed of jet propulsion. He tosses a mean pair of ivories, and so far as we know has only two enemies in the world—Big Dick and Little Joe. His place was taken on the return journey by his right hand man, Knight Templeton, just returned from Peru, Ecuador, Colombia, Venezuela, and Trinidad, and full of gratitude to the oil people down in the Latin-Americas for their courtesy and helpfulness. Knight is a golfer of parts and is justifiably proud of the fact that in a recent joust he hit the ball in one.

Actually, the pullman was literally jelled with divot lofters, and heaven knows what would have happened had there been room to swing a driver. Ralph Clemons, the Bethlehemite and well known scion of San Gabriel Club, was there as large as life. His booming baritone, indeed, gave substance to many a reedy quartet. Like Paul Cavins, Ralph expected to be back home just in time to see his son married. Which recalls the fact that when a girl in Scotland becomes engaged to a McIntosh, her friends give her a shower. Occasional visitors in the club car, by the way, were Norman Dorn, the Lane-Wells exec and his lovely wife, who appeared to be greatly entertained by the Daughters of the Nile aforesaid. Norm was later initiated into the mysteries of Brasso and according to all reports gives promise of blossoming into a Brasso profundo.

The only other person on the Special so far as we can remember was a right amiable colored chap by the name of Mr. Porter, who took care of our travel needs in good shape and then spent eight days sunning himself on the platform at Tulsa. Every time we came down to the tracks to roost, we asked if there was anyone on the train. Always we received the same answer, "Yassuh. Mistah Frosty he aboahd, suh." Anyway, the whole deal was very enjoyable. It is a long time since we traveled so far from home, but on the other hand our mind has never ceased to ramble.

## Geist again heads Allis-Chalmers

Walter Geist was elected to his seventh term as president of the Allis-Chalmers Manufacturing Company and all directors and officers were re-elected at the annual meeting of the firm's stockholders and board of directors. Directors renamed by the stockholders are James M. Barker and James D. Cunningham, Chicago, Illinois; Arthur W. Butler, New York, New York; Hugh Comer, Sylacauga, Alabama; Ernst Mahler, Neenah, Wisconsin; Leigh Willard, Cleveland, Ohio, and W. C. Buchanan, Geist, W. C. Johnson, Walter Kasten, Louis Quarles, and W. A. Roberts, all of Milwaukee.

In addition to Geist, the officers named by the board of directors are Roberts, executive vice president in charge of the tractor division; Johnson, executive vice president in charge of the general machinery division; J. A. Keogh, vice president and comptroller; H. W. Story, vice president and general attorney; W. E. Hawkinson, secretary and treasurer; E. H. Brown, vice president in charge of engineering development; Marshall L. Noel, vice president and general sales manager for the tractor division, and J. L. Singleton, vice president and director of sales for the general machinery division.

Other officers chosen by the board are J. F. Ryan, assistant secretary and assistant treasurer; C. P. Allendorf, assistant comptroller; N. D. Johnson, assistant secretary, and G. F. Langenohl, assistant treasurer.

## Changes in store managers

Several changes in Oil Well Supply Company store managers have been announced by Mark Barkhurst, manager of this U. S. Steel subsidiary's Mid-Continent Division.

Ralph H. Coplin, storeman at the McPherson, Kansas, store since January 1, 1948, has been appointed manager of that store. Coplin succeeds Clarence W. Morrison, Jr., who has transferred to Wewoka, Oklahoma, as store manager.

C. E. Lance, Wewoka, Oklahoma, store manager for the past year, has been appointed store manager at Seminole, Oklahoma. He succeeds G. T. Way, who has transferred to the Gulf Coast Division's Natchez, Mississippi, store.

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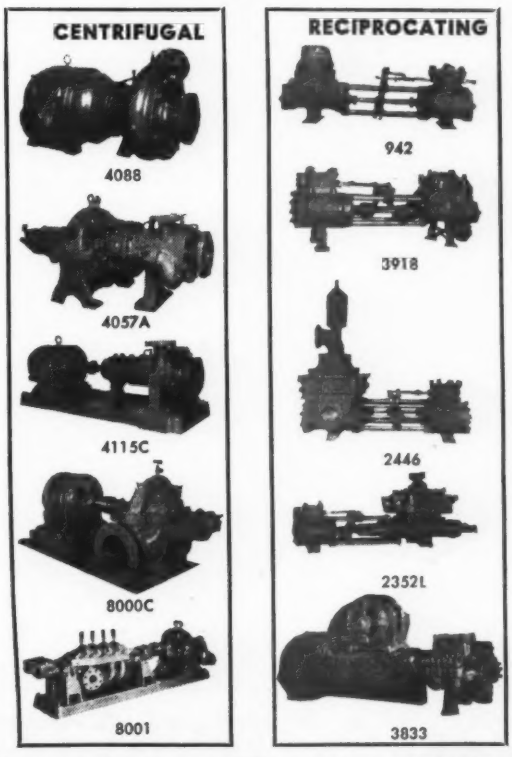


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## Continental Supply promotes three

F. M. Mayer, president of The Continental Supply Company, Dallas, Texas, has announced the promotion of three executives to new positions. The changes became effective June 1.

D. D. Dellinger, treasurer of the company since 1940, has been elected to the position of vice president in charge of finance. He will continue serving as treasurer.

Noble A. Endicott, for the last six years sales manager, has been elected to the position of vice president in charge of Gulf Coast operations, with headquarters in Houston.

Jack A. Mussler, since 1939 manager of the tubular division, has been appointed general manager of sales, a newly created position.

Dellinger joined Continental in 1933. Prior to that time he was engaged in a family business in Ohio. After becoming

Noble Endicott

D. D. Dellinger

Jack Mussler

associated with Continental he served in the capacity of assistant treasurer until his elevation to treasurer in 1940.

Endicott entered the services of Continental in 1916 as a ledger clerk in the accounting department. In 1919 he went to Ranger as a field man, remaining in field work continuously until January, 1936, when he was transferred to the general offices in Dallas. During that period he was for a time in charge of the company's Canadian operation. After entering the Dallas office he was appointed assistant manager of sales, becoming sales manager in 1942.

Mussler became associated with Continental in 1935 as district manager of tubular sales, Houston. He was previously connected with Youngstown Sheet and Tube Company, having joined that organization in 1923 at which time he entered the Youngstown Sales School. In 1926 he was transferred to Tulsa to serve in sales promotion. In 1929 Mussler went to Europe, the Middle and Far East in the interests of Youngstown Sheet and Tube Company. In 1932 he was transferred to Houston and in 1935 he joined Continental as district manager of tubular sales.

## Cahill to engineering staff

C. K. Hubbard, assistant to the vice president of sales of the Rockwell Manufacturing Company has announced the appointment of Frank J. Cahill to the engineering staff of the Nordstrom Valve Division. Cahill's assignment as a new applications engineer for Nordstrom valves will be to cover the petroleum refinery field in general with his efforts concentrated in the eastern states and headquarters in New York City.

He obtained his B. S. degree in mechanical engineering from Tufts College in 1937. Shortly after graduation he joined the M. W. Kellogg Company and was with this firm for ten years. During this time he became very familiar with Nordstrom products and their application in refineries.

## E. O. Shreve retires

Earl O. Shreve, vice president of the General Electric Company on the president's staff and president of the U. S. Chamber of Commerce, has retired from the company after 44 years' service, it is announced by Charles E. Wilson, G-E president.

Shreve has been on special assignments with headquarters in New York. He previously was in charge of customer relations.

A native of Mapleton, Iowa, Shreve was graduated from Iowa State College in 1904 with the degree of B.S. in electrical engineering. He joined General Electric as a student engineer on the Test Course at Schenectady that year.

● **The Design and Construction of Pressure Relieving Systems,** *Engineering Research Bulletin No. 31, by D. L. Katz and Nels E. Sylvander. University of Michigan Press, 311 Maynard Street, Ann Arbor, Michigan. Pages, 150. Price, $3.*

Results of a two-year study of pressure vessel protection requirements in oil refineries and gasoline plants, for use in designing, constructing, and installing systems are published in this bulletin. The work was part of an engineering research project sponsored by API.

In order to obtain data 33 refineries and gasoline plants were visited to observe worthy practices. Engineering principles governing the various aspects of pressure relief have been reviewed and coordinated. Fluid flow formulas for relief devices have been re-derived. A comparison of methods of prediction of causes of overpressure, selection of size and type of device, disposal, and other facets of relief systems are considered. Example calculations are presented for such items as relief area, heat input, and piping for relief devices.

● **The Permian Basin Oil Directory—1948,** *by Burmass Sales Company, 601 W. Wall, Midland, Texas. Pages, 84. Price, $3.*

Oil producers and drilling contractors of the Permian Basin are indexed in this new directory. The company names are given in alphabetical order with the executive and operating personnel, office location, post office box, and telephone number listed. A handy, pocket-size directory.

● **Historical Account of the Petroleum Industry of Roumania** *and* **Preliminary Considerations on the Exploratory Drilling in Roumania During the Period 1900-1947,** *by Mihail Pizanty. Monitorul Petrolului Roman. Bucharest, Roumania.*

A pamphlet in the French language, organized by M. Pizanty, director of the Monitorul. The historical part comprises some unpublished documents for the years 1785-1822 relative to property rights on petroleum producing lands and also some official articles on the export of crude petroleum in 1825 by the Roumanian Principalities. Two chronological tables of the exploitation of petroleum between 1857 and 1903, and a list of the refineries installed between 1840 and 1907 are given.

The second study covers exploratory drilling by regions and lists the name, date, depth, tubing, geological formations and cumulative production for each of the 530 wells.

● **Technical Publications, Year-1946.** *Standard Oil Company (New Jersey) and Affiliated Companies. Pages, 356. Limited distribution.*

Twenty-three articles by members of the Standard Oil Company and its affiliated companies, previously printed in technical publications, are assembled in this volume. Various research and development accomplishments offer a revealing glimpse of the wide diversity of the problems which come within the purview of a petroleum technologist.

The object of this reprint is to bring together certain technical articles of interest to scientists, teachers and students. By distributing these publications it is hoped that inspiration will be provided for increasing the number of contributions to the trade and scientific journals.

● **Chemical Engineers Handbook.** *John H. Perry, editor-in-chief. McGraw-Hill Book Company, 330 West 42nd Street, New York 18. Pages, 3029. Price, $12.*

Data needed in routine problems of design and practice, or in investigation of special problems are presented in this revised, second edition. Concise descriptions and working fundamentals of processes and equipment, together with comprehensive formulas and equations, charts, tables, data, and schematic diagrams provide a complete and efficient reference book. It covers not only chemical engineering but related fields so important to all connected with this profession. The thumbnail index for 29 sections assures quick selection.


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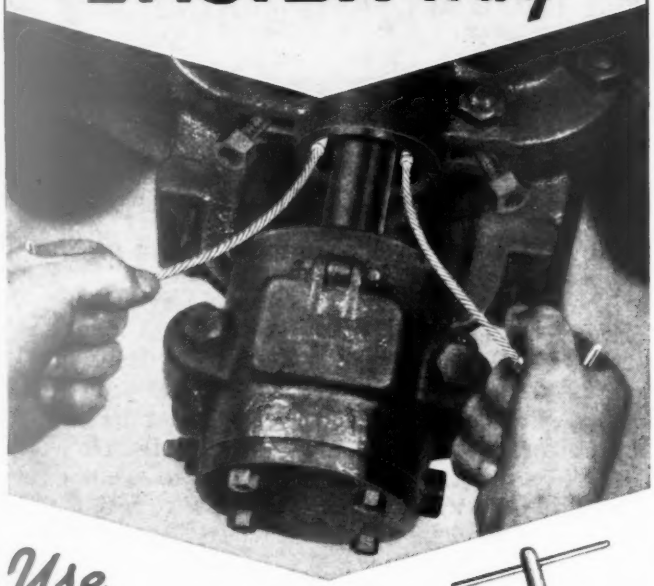

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Left to right: E. G. McConnell, Mid-Continent manager; O. Suter, chief engineer; H. H. Peters, vice president; J. B. Wood, president.

## Toteo representatives meet

J. B. Wood, president, and H. H. Peters, vice president, of the Technical Oil Tool Corporation, Ltd., held a two-day sales and service meeting for their company representatives early in May at the Baker Hotel, Dallas, Texas. The company is increasing its staff in order to offer more service to oil field operators, Peters said. Seventeen company representatives attended the meeting.

## Tulsa speeches recorded

A unique feature at the International Petroleum Congress held in connection with International Petroleum Exposition in Tulsa was the recording of all speeches and addresses by Sound Scriber on paper-thin plastic disks. Copies of the records were made by the Sound Scriber Company and were supplied to any one requesting them, and without charge. This enabled listeners to obtain and preserve for their own use any particular speeches they were interested in or to play to other members of their firms that were unable to attend the Congress.

Sound Scriber is primarily designed for dictation but it is also used for retelephone conversations, interviews, and conferences. The disks are indestructible and can readily be filed. In telephone recording the equipment provides a confirmation of the conversation and eliminates any possible error and for this reason lends itself ideally to oil production reports, geological reports, pipe line runs, sales orders, etc. Sound Scriber has a portable model that weighs only 20 lb and can be used in automobile, train, hotel, or wherever there is an electrical outlet.

## New Larkin warehouse

A new and greatly expanded warehouse was recently completed by Larkin Packer Company, Inc., at 413 East Scott, Wichita Falls, Texas, in order to better serve the North Texas, Panhandle and Southern Oklahoma area, W. H. Larkin, president, announces.

The new Larkin warehouse is a 40 ft by 80 ft quonset type building. The building includes warehouse and office space as well as living quarters for the Larkin warehouse representative, Jim Ellis.

L. E. Vessels has been named the district Larkin sales representative for the Wichita Falls area. Before he joined the Larkin sales organization, Vessels represented various oil tool manufacturers in South America. Prior to that he was store manager for Wilson Supply Company at Harvey, Louisiana, and was employed at one time by the American Iron and Machine Company, Harvey.

## O. J. Fister to Oil Well Supply . .

Appointment of O. J. Fister as assistant to vice president of Oil Well Supply Company, with headquarters at Oil City, Pennsylvania, has been announced by L. H. Keim, vice president of this U. S. Steel subsidiary.

Fister has been with U. S. Steel since 1935, starting with Federal Shipbuilding and Dry Dock Company at Kearny, New Jersey. He has been assistant manager of industrial relations at Federal since 1943.

## A. M. Kuehmsted gets new post

The Santa Fe Tank and Tower Company of Los Angeles has announced the appointment of A. M. Kuehmsted to head its cooling tower division. Kuehmsted first entered the employ of the company in 1936 as an engineer in the cooling equipment division. He was later appointed division manager, a post that he held for six years. During the war, Kuehmsted distinguished himself as chief engineer in charge of Santa Fe wood tank production for the armed forces.

A. M. Kuehmsted

Early last year, Kuehmsted opened the New York office for Santa Fe, and just recently turned that office over to Herbert Kunan in order to take on his new duties at the main office in Los Angeles.

As chief engineer of the cooling tower division, Kuehmsted will coordinate the activities of the branch offices at San Francisco, Houston, Tulsa, and New York.

## Halliburton makes changes

Halliburton Oil Well Cementing Company, Duncan, Oklahoma, has announced the following transfers and promotions:

Hubert Northcutt, superintendent of the eastern division with headquarters at Flora, Illinois, has been transferred to Dallas, Texas, where he will take charge of the East Texas division.

Robt. W. Mitchell, formerly assistant superintendent of the eastern division, has been promoted to superintendent of that division and will maintain headquarters at Flora.

H. P. Hearn, superintendent of the East Texas division, has been transferred to Denver, Colorado, where he will assume the duties of superintendent of Rocky Mountain division.

C. O. Pace, formerly superintendent of the Rocky Mountain division, has taken a temporary sick leave.

## Export sales representative

D. T. O'Connor has established an office at 500 Fifth Avenue, New York, N. Y., as export sales representative for the Shaffer Tool Works of Brea, California. Shaffer was formerly represented by E. L. Carter with whom O'Connor was associated for the last five years.

O'Connors' experiences include 18 years in foreign fields on production and drilling jobs in Venezuela, Bahrein, and Trinidad, and three years in Rodessa, Louisiana, where he owned and operated a field machine shop.

## Purchases Mattoon plant

The purchase of the Atlas Imperial Diesel Engine Company plant and facilities at Mattoon, Illinois, is announced by F. M. Young, president of Young Radiator Company. The Young Radiator Company manufactures heat transfer products and has large plants and offices at Racine, Wisconsin, with sales and engineering offices in principal cities from coast to coast.

Young states that plans are being made to build additional facilities at Mattoon to accommodate increased production and expansion of the company's line of large "VAD" vertical air discharge cooling and condensing units, jacket water coolers, and other products.

## Twin Disc Tulsa office moved

The Tulsa, Oklahoma, branch sales engineering office of the Twin Disc Clutch Company has been moved to 2910 East 15th Street in Tulsa from its former location at 310 East Fourth Street.

The Tulsa branch office is in charge of Wade A. Eskridge, assistant district manager, and is headquarters for Twin Disc sales and service in Oklahoma, Kansas, Missouri, and Colorado.

## Promoted to California sales

George D. Dwyer former manager of export order department has been promoted to California sales by the Oil Tool Division of Byron Jackson Company. Dwyer joined BJ in 1941. After Army service he rejoined BJ as expediter. In May, 1947, he was promoted to manager of the export order department.

Dwyer completed an extensive shop training course in March. He will operate out of Los Angeles.


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Maintenance or repair service is never a problem with users of Young Oil Field Cooling Equipment. Young oil field distributors, such as The Happy Co., co-engineer in the above application for Clark Bros. Co., Inc., Olean, N. Y., are easily accessible for service and replacement parts with branches at strategic points throughout the Mid-Continent oil fields. Take advantage of the experience of more than two decades' specialization in research, engineering and manufacturing . . . use Young Quality Heat Transfer Products.

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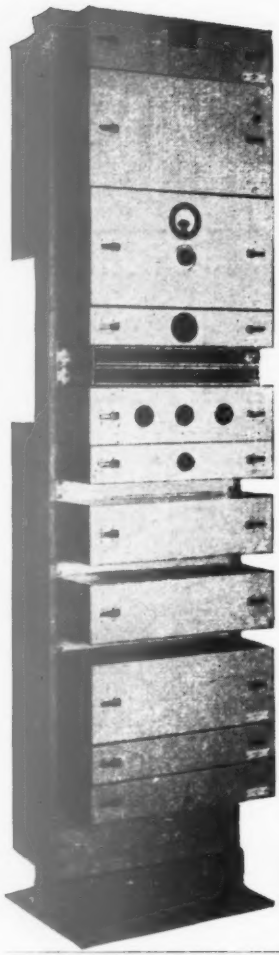
Michigan Area: H. J. Young, 1364 Lake Shore Drive, Muskegon, Michigan



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## East Texas AIME officers

Newly elected officers of the East Texas Section of the AIME: Seated, D. W. Akins, Jr., Ohio Oil Company, Shreveport, chairman, and Don M. Kerr, Kerr Engineering and Construction Company, Kilgore, vice chairman; standing, Phil J. Lehnhard, East Texas Engineering Association, Kilgore, director; Jack M. Shepherd, Humble Oil and Refining Company, Tyler, secretary-treasurer; Woodrow W. Leonard, Youngstown Sheet and Tube Company, Shreveport, director; R. T. Wade, Schlumberger Well Surveying Corporation, Shreveport, director; Ralph Ludwick, Stanolind Oil and Gas Company, Greggton, director, and L. H. Dial, East Texas Salt Water Disposal Company, Kilgore, director.

## Brown Instrument expansion plan

A $2,500,000 expansion program, announced by Brown Instrument Company, Philadelphia, will add more than 60 per cent to its present manufacturing space and a proportionate increase in employment, said Henry F. Dever, president.

The program includes construction of a four-story addition to the main plant at Wayne Junction. The first phase of the project is scheduled for completion next March, Dever said. The foundation and footings of the new wing are designed so that four additional floors may be added at a later date.

When completed, the first four-story structure will enable the company to combine some of its outlying leased sites and simultaneously provide needed space and production facilities.

## Dallas Geophysical Society elects

The Dallas Geophysical Society recently elected new officers. W. W. Newton, Geotechnical Corporation, was elected president; K. E. Burg, Geophysical Service, Inc., first vice president; D. Ray Dobyns, Magnolia Petroleum Company, second vice president, and W. G. Smiley, Sun Oil Company, secretary-treasurer.

A. E. McKay, The Atlantic Refining Company, past president of the society, was elected district representative of the Society of Exploration Geophysicists. Paul E. Nash, Magnolia Petroleum Company, was also elected district representative.

## PIWC pipe line map reissued

When the Petroleum Industry War Council was dissolved, W. R. Boyd, Jr., as trustee and liquidation agent, entrusted to Shell Pipe Line Corporation and L. L. Ridgeway Company, respectively, the tasks of keeping up to date and printing the two U. S. pipe line maps underwritten by the council.

With data supplied by line owners, the map covering Central United States has been revised by Shell as of May 1, 1948. Interesting newer lines added or concisely located are Magnolia 20-in. Corsicana-Patoka line, Basin 20-22-24-in. Jal-Cushing line, Ozark 22-in. Cushing-Wood River-Patoka line, Wyco 8-in. Casper-Denver products line, Sinclair 8-10-in, Houston-Wood River products line, Magnolia 12-in. Beaumont-Hearne products line, Texas 8-10-in. Hearne - Dallas - Fort Worth and 6-8-in.

Hearne-Austin-San Marcos products lines, Standish converting Mex-Tex line to crude oil service and various shorter extensions.

Prints of the revised Central United States map can be obtained direct from L. L. Ridgeway Company, 615 Caroline Street, Houston 2, Texas. The map covering Eastern United States is now being brought up to date.

### James L. Mahon retires

American Car and Foundry Company announces the retirement of James L. Mahon, district manager of its Detroit, Michigan, plant. Mahon has been associated with the company for more than 40 years, having entered its employ as a car clerk in 1898.

### South American sales representative

J. E. (Jimmy) Berry, former drilling superintendent for Shell Oil in Venezuela, has recently been made a sales representative for Oil Center Tool Company in South America and will have his headquarters at Maracaibo. In a recent news story it was stated incorrectly that Berry would be drilling superintendent for OCT at Maracaibo. As a manufacturing and sales firm, of course, Oil Center Tool Company does not employ any drilling superintendents.

### Consolidate headquarters

Houdry Process Corporation has consolidated its executive, sales, and engineering headquarters in Philadelphia. Dr. C. C. Peavy, vice president in charge of sales and engineering, and Robert M. Cornforth, sales manager, are making their headquarters at the main office, 225 South 15th Street, Philadelphia.

### Elected director and vice president

E. J. McMahon, production manager of the Dearborn Chemical Company, was elected a director and vice president at the annual stockholders' meeting in Chicago. He succeeds John W. Brashears who has been with Dearborn Chemical Company 52 years, a member of the board of directors since 1912, and who was retired as an honorary director for life.

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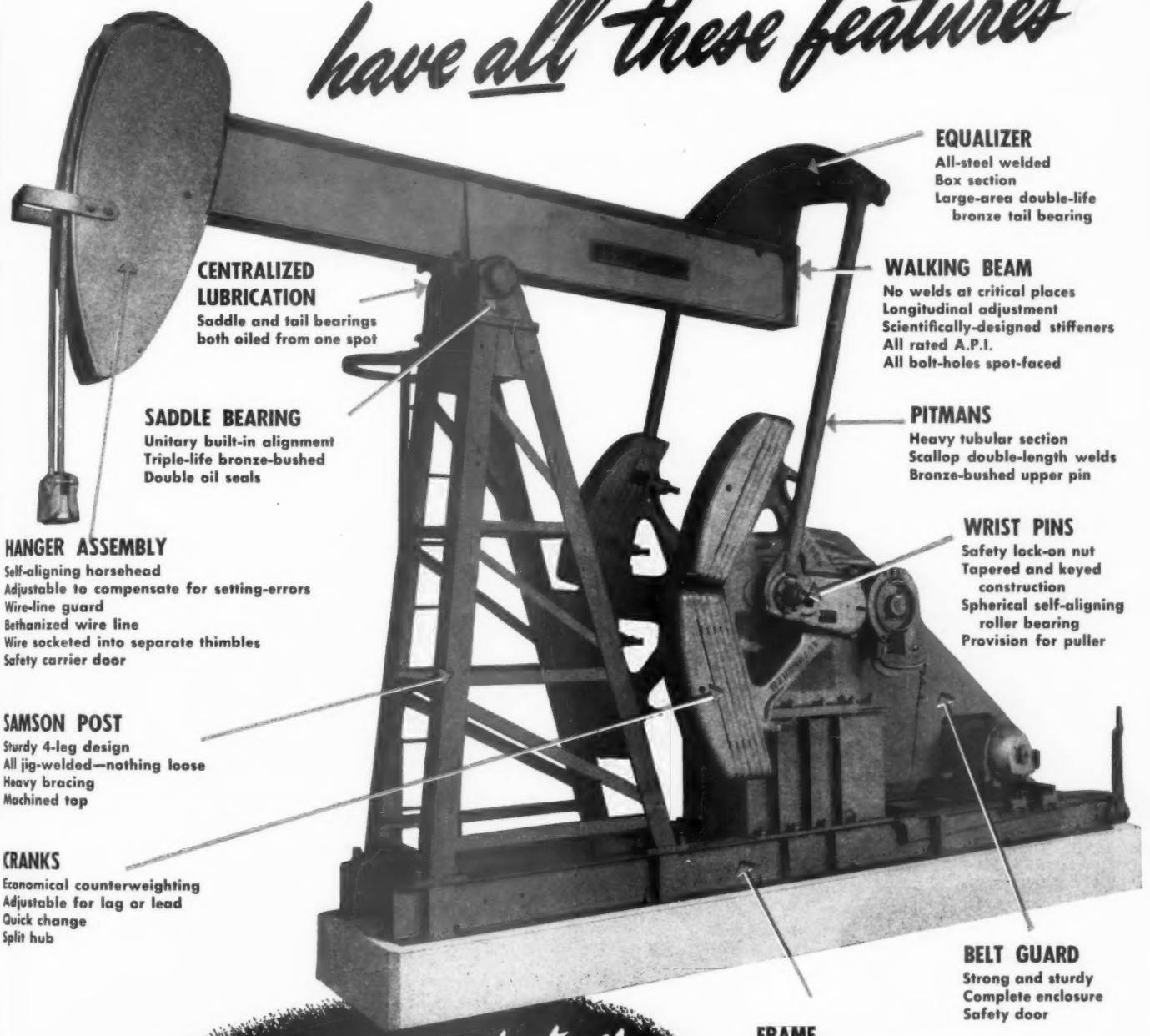

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